Technology transfer from polytechnics and universities in Germany. Some «best practices»

In this paper we study «best practices» of some German institutionalised transfer models directly based on the experience available in the educational institutions. Our paper addresses three major questions: (1) How is the model organised and for which agents does it work? (2) What are the main critical success factors of the model and which are the constraints or requirements for a good implementation in other countries or regions? (3) What is the level of success of the model? Our analysis includes the Steinbeis model of technology transfer, the Institutes of Applied Research, and the Research Campus - Partnerships for Innovations. Analysing critical success factors and the transferability of the German technology transfer models we have to take into account the difference of the economic and educational model and the potential of the innovation system. Therefore the introduction of similar models in other countries, like the case of Spain, has to take such differences into account by adapting the models to national or local circumstances.

En este artículo analizamos las «mejores prácticas» de algunos modelos de transferencia institucionalizados alemanes basados directamente en la experiencia disponible en los centros de enseñanza. Nuestro artículo aborda tres importantes cuestiones: (1) ¿Cómo está organizado el modelo y para qué agentes funciona? (2) ¿Cuáles son los principales factores críticos de éxito del modelo y cuáles las limitaciones o requisitos para una buena puesta en práctica en otros países o regiones? (3) ¿Cuál es el nivel de éxito del modelo? Nuestro análisis incluye el modelo Steinbeis de transferencia de tecnología, los Institutos de Investigación Aplicada y el Research Campus-Partnerships for Innovations. Al analizar los factores críticos de éxito y la capacidad de transferencia de los modelos de transferencia tecnológica alemanes tenemos que tener en cuenta la diferencia del modelo educativo y económico y el potencial del sistema de innovación. Por lo tanto, la introducción de modelos similares en otros países, como en el caso de España, tiene que considerar dichas diferencias a la hora de adaptar los modelos a las circunstancias locales o nacionales.

Artikulu honetan ikastetxeetan eskuragarri dagoen esperientzia zuzenean oinarrituta dagoen instituzionalizaturiko transferentzia alemaniar eredu batzuen «jardunbiderik onenak» aztertzen ditugu. Gure artikuluak hiru kontu garrantzitsuri heltzen die: (1) Nola dago antolatuta eredua eta zein agenterentzako lan egiten du? (2) Zeintzuk dira ereduaren arrakastaren faktore kritiko nagusiak eta zeintzuk beste herrialde edo eskualdeetan praktikan ongi jartzeko mugak edo baldintzak? (3) Zein da ereduaren arrakasta-maila? Gure azterketak teknologiaren transferentziarako Steinbeis eredua, Ikerketa Aplikatuko Institutuak eta Research Campus-Partnerships for Innovations barne hartu ditu. Arrakastarako faktore kritikoak eta teknologia-transferentzia eredu alemaniarren transferentzia-gaitasuna aztertzerakoan, kontuan izan behar dugu hezkuntza eta ekonomia ereduen eta berrikuntza sistemaren ahalmenetan dagoen aldea. Beraz, antzeko ereduak beste herrialde batzuetan ezartzeak, Espainian kasu, kontuan hartu behar ditu alde horiek, tokiko edo herrialdeko baldintzetara egokitzerakoan.

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Table of contents

1. Introduction
2. Traditional transfer mechanisms for SMEs in Germany
3. New instruments for public private technology transfer: «Research Campus - Partnerships for Innovations»
4. Final remarks

Bibliographic references

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1. **INTRODUCTION**

This paper analyses some specific technology transfer models based on the German vocational education and training system highlighting some «good practices» of the polytechnic schools or universities[1] (PS&U from now on). One of the core elements of innovation policy in Germany is the strengthening of collaboration between universities and industry and the improvement of networking and transfer. Each of the three models presented in this paper do take into account the further vocational qualification and dual training in the handling of new technologies. In these models, both universities and firms are jointly engaged in these training and qualification activities.

In section 2 we explain some German traditional technology transfer (TT) mechanisms existing since the late 1980ies focussed especially on small and medi-

[1] «Fachhochschulen» or «Universities of Applied Sciences».

um sized enterprises (SMEs): The Steinbeis Model and «An-Institutes». In both examples the duality of training and education is an important aspect because students can participate in the projects, this is especially the case for the activities of the «An-Institutes» whose activities have to be adapted to the needs of the PS&U, especially their students.

In the last years a broad discussion is going on about the introduction of more business-driven TT activities in order to intensify evaluation, and commercialization activities and thus to generate income from public research. This new discourse around strategic long-term models of science industrial cooperation on R&D (Koschatzky and Stahlecker, 2010) led to the development of the German «New High-tech Strategy» (BMBF 2014). Kroll (2016, p. 1) argues that the novelty of the strategic approach is based on three aspects: (1) they address long term pre-competitive agendas for future challenges, (2) they have a long term perspective (over five years or more) and (3) they aim at an intensity of integration that is typically not given in the business driven clusters that primarily understand themselves as mediators. However, the new models aim, among others, at the creation of experience and expertise in new relevant emerging sectors. In this respect, leading-edge clusters or research campus models are used as instruments in order to achieve the overall strategic objectives. In section three we will describe an example of those new long term proactive models analysing the German «Research Campus: Public Private Partnership for Innovation». In this respect, one important activity is the «Research Campus» programme. A research campus includes both large companies and SMEs (which are the majority), universities and non-university research institutes and is, besides long-term oriented research, focused on education (students, Ph.D. students). As described in section 3, new forms of collaboration between universities and firms in research, training and education are a major characteristic of this initiative. Finally, in section 4 we will draw some general conclusion.

In this article we try to answer the following questions. (1) How is the model organised and for which agents does it work? (2) What is the level of success of the model and how is it measured (do evaluation reports exist)? (3) What are the main critical success factors of the model and what are the constraints or requirements for a good implementation in other countries or regions?

2. TRADITIONAL TRANSFER MECHANISMS FOR SMES IN GERMANY

2.1. Technology transfer policies in Germany

In Germany there exists –since the late 70ies/early 80ies- a broad number of technology transfer models in a well-defined institutional setting and some are considered «examples of 'best practices'». An example of institutional funding for conversion of (public) research in applied innovation ready for use is the case of the

Fraunhofer Model[2]. Some good examples of program funding are: the EXIST Program for university technology spill-overs and its risk capital schemes for spin-offs. A good example of private initiative is the Steinbeis Model, clearly focused on innovation in SMEs.[3]

In the landscape of the technology transfer from the German PS&U three complementary organisational modalities can be distinguished. On one hand the business-driven Steinbeis Model based on a network of small purely private Steinbes Centres(SBCs). Although they are often located within the PS&U they operate on the basis of private contracts with firms. A second organisational mode is the so called «An-Institutes» [4]. being – often- small institutes contractually affiliated to PS&U, albeit carrying out activities like research, development, transfer or training independently of their parent organisation (Koschatzky *et al.* 2008).The Private Steinbeis Centres do carry out activities with total independence of the interest of the PS&U while the activities of the An-Institutes require direct interests for the PS&U, contributing to the training of students or enable the extension of existing research lines of the «Fachhochschule». In the following pages we will discuss different aspects of these two different models.

2.2. **Steinbeis Model versus «An-Institutes»**

*2.2.1. **How is the model structured and for whom does it work?***

Steinbeis Transfer Centres and the «An-Institutes» are based on independent units that take advantage of the existing structure of the PS&U to supporting the technology transfer. The SBCs and the «An-Institutes» are attractive models because they reach SMEs that -on most of the occasions- do not have access to other policy instruments or are too small to obtain interest of the bigger Technological Institutes. Both are focussed on small projects or problem-solving activities[5]. Often SMEs do not apply for assistance for a specific project, rather they require an audit of their firm and/or their market in order to design a strategy or to solve -often latent- problems. In such cases they ask themselves what is the question that has to be solved.

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[2] Fraunhofer is based on nearly (up to date) 70 technology institutes with different sizes and research topics competing on the research market and serving the needs of industrial and public clients including smaller projects for SMEs and large long term projects for larger clients.

[3] For a review of several of those models in Spanish, see Heijs *et al.* (2009), Baumert and Heijs (2007, 2008) (http://eprints.ucm.es/7982/1/64.pdf) In English we recommend Frietsch and Schubert (2012).

[4] A third kind of Institutes are the so called Applied Research Institutes (Institut for angewandte Forschung) with a large variety of structures, size and type of activities which make it difficult to offer a global description.

[5] Although the «An-Institutes» have a broad reach of activities and clients including also larger firms.

The Steinbeis (SB) model for technology transfer is basically centred on the development of technologies for SMEs and are mainly managed by researchers and experts of the PS&U[6]. They use the endogenous existing capabilities (experts) and resources (technological infrastructure and equipment) in universities and polytechnics in order to improve the technological competitiveness of the firms in the region or country. Initially it was a regional model of Baden-Württemberg and since 1990 its activities expanded throughout Germany. In 2016 SB had over 1.000 «Technology Transfer Centres» with a turnover of 157.1 million Euros in 2016 based on over 6.000 employees. As expressed by the Steinbeis Foundation, its network of small specialized transfer orientated centers in a broad spectrum of the latest knowledge of technology and innovation management applicable to firms by competitive market practices offers comprehensive, customer-oriented solutions. «Steinbeis offers tremendous knowledge potential and a wealth of on-the-job experience in all fields of technology, business administration and end markets. It is this diversity of experience that allows us to offer end-to-end solutions matched to customer requirements»[7]. Moreover, Steinbeis offers the possibility to found subsidiaries or spin-offs for the commercialization of their own products or technology oriented startups (Auer, 2007; STW, 2009). As will be explained, the Steinbeis model is based on several basic aspects to assure its success. A business-driven entrepreneurial approach, flexibility in opening or shutting down SB centres, preservation of its independence based on a deliberately very low level of public finance and a high level of decentralisation (Auer, 2007; Ortiz, 2015a).

Also the «An-Institutes» at universities or universities of applied sciences are a regional model of knowledge and technology transfer to the enterprises based on the experience and know-how of the PS&U. Since the eighties they have had an important role for technology transfer, applied research, technical consultancy, long life learning, and testing and qualifying. In this way, they act as a bridge between basic research and business-oriented innovation (Koschatzky *et al.*, 2007). They are small independent units often created to assure a more dynamic and flexible administrative functioning and a more dynamic structure in order to take on a rapid way advantage of the changes in the markets.

Although both technology transfer models emerged in the 1980ies a clear difference exist. Steinbeis is a private organization directly working for SMEs, while An-Institutes have a much broader transfer focus, covering all scientific disciplines: from technical sciences, natural sciences, social sciences, religious science to medicine and are thus much more diverse in their activities (studies, qualification, education, experimental development etc.) than the Steinbeis Transfer Centers. The moti-

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[6] For a good description of how the projects of the SBCs are carried out see Ortiz, 2015b.

[7] Source: Steinbeiswebpage (downloaded May 2007) http://www.stw.de/en/about-steinbeis/philosophy.html).

Table 1. **STEINBEIS: BASIC FACTS**

	1987	1992	1997	2002	2007	2009	2012	2016
Employees	198	802	1175	988	1340	1764	1572	1764
Contractors	1088	1168	1798	2440	3348	3581	3697	3581
Professors	687	597	599	786	957	700	752	700
Total	1973	2567	3572	4214	5645	6045	6021	6045
Turnover	4,97	32,41	63,95	80,86	108,55	124,5	141	157,1
Number of institutes	68	158	320	516	739	767	918	1064
Average size by turnover	73.088	205.127	199.844	156.705	146.888	162.321	153.595	147.650
Bigger SBCs (20%)[1]	292.353	820.506	799.375	626.822	587.551	649.283	614.379	590.602
Smaller SBCs (80%)	18.272	51.282	49.961	39.176	36.722	40.580	38.399	36.913
Average size by employees	29	16	11	8	8	8	7	6
Turnover by employee	2.519	12.626	17.903	19.188	19.229	20.596	23.418	25.988
Weight of professors	34,8%	23,3%	16,8%	18,7%	17,0%	11,6%	12,5%	11,6%

Source: several reports of the Steinbeis Stiftung, especially the reports on 25 and 30 years' existence of Steinbeis

vation of Steinbeis is to intensify the linkages between the «Fachhochschulen» and firms, and for the professors involved to earn an additional income. The motivation of the foundation of An-Institutes was to find a more flexible framework for research and other activities, funded by external parties, than it was possible within the university and their strict budgetary rules. However, since 2005/2010 universities are much more flexible and the new rules for PS&U imply new forms to assure a more dynamic behavior for cooperation with the business sector, and there is no real need any more to have an entity related to the university but situated outside.

In 2008[8] 544 «An-Institutes» were identified as such, with on average 20 employees of whom 60% were scientists (Koschatzky *et al.* 2008). However, for a good comparison in the context of this paper, the «An-Institutes» (AI) of the universities should be excluded. Analyzing only the data for «AI» on the Polytechnics, a quite different situation is revealed, with around 8 persons and each of them with a budget of around 24,550[9]. Concluding, their size in Fulltime Equivalent was in 2007 very similar to the size of the SBCs in terms of Head Counting. In budgetary terms the AI received 489 million Euros in 2004, representing for around 1.7% of the budgets for Polytechnics and the Research Organizations External to the Universities. The Steinbeis obtained 22% of the budget of the «An-Institutes. These data reveal that both types of institutes are not really big players, however, they have an important niche in the market –especially focused on SMEs and problem-solving projects- based on long term relationships and its image as a reliable partner built up in the last three-four decades.

Some important differences exist in the organisation form of both types of institutes. First, the SBC are autonomous self-regulating «firms», acting as independent firms with a clear business orientation while the «An-Institutes» are mostly non-profit organizations and only independent in administrative terms. They are always officially recognized by the PS&U due to an official cooperation involving the following requirements (German Science Council, 1986): (1) the Polytechnic has a clear influence on their activities; (2) their academic research orientation has to be independent from the funders of AI; (3) The AI follow the scientific criteria and norms of the polytechnics; (4) the AI are financed by private resources and do not receive funds from the polytechnics; (5) the polytechnics are not responsible for the debts generated by the AI and (6) the use of the installations and equipment of the polytechnics are based on the common rules. Nowadays the PS&U are ruled by new flexible norms but still the AI are always semi-independent organizations based on the mentioned cooperation agreement and are not financed with financial resources of the PS&U. Concluding, they are clearly intertwined with the polytechnics in terms of personal, cooperative projects and research areas and also in geographical terms close to each other.

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[8] No recent global data on «An Institutes» is available.

[9] Data for the AI are based on Full Time Equivalent (FTE) and for the SBC on head counting (HC) and include a large number of part time researchers.

2.2.2. Advantages and complementarities of SBC versus AI

As mentioned, the Steinbeis Foundation focuses on solving technical problems of SMEs (Hassink, 1992) with entrepreneurial and market-based funding mechanisms (Ortiz, 2015a). The Foundation has three basic –but interrelated- management principles. First of all, they have a clear market-based demand orientation and one requiring high quality standards. Secondly and directly related with the market orientation, they have a strict policy of flexibility in opening and closing centres. The choice of new activities or centres is based on the importance of the technological fields or specialisation for local firms and the future growth potential. The third principle is self-financing: The decentralised SBCs have to respond to the existence of a real demand in the market. In the event that this demand disappears the centre will also be closed down. The SBCs are small institutes located in PS&U which means a low level of fixed overhead costs and only centralizing what is absolutely necessary. The bureaucracy generated by the Steinbeis hierarchy is a small number of standard formal procedures, delegating entrepreneurial responsibility while at the same time providing general pointers. Only one thing is standard to each project: confidentiality, from start to finish.

The main advantage of the Steinbeis Model –in comparison to the «An-Institutes» and IAF[10] model- is its total independence from the polytechnics. Especially this is because they do not have the obligation to publish their research results and the researcher can charge –without any problem- for his/her services. In other words, they generate extra income for researchers. Moreover, the contracts channelled by the Steinbeis model have more administrative flexibility in financial terms, because their contracts do not have to meet transparency and legal standards obligated for public bodies like the polytechnics. Also in organisational terms there is an advantage because there are no requirements to review the applied characteristics of the projects. In other words, the projects do not have to fit in the main criteria of R&D projects of the PS&U. The disadvantage of the «Steinbeis projects» is that the researchers have to pay for the use of the infrastructural facilities of the PS&U and the researchers and teaching staff of the SBC cannot reduce their teaching hours due to their involvement in the projects. On the contrary, the researchers involved in projects of the «An-Institutes» or Applied-Research Institutes (IAF) can make(or at least could make in the past[11]) a free use of the existing facilities and are allowed a reduction to be made of up to 50% in teaching load. However, on the other hand, they have the obligation to publish results; the researcher receives no payment and they have less financial and organisational flexibility because they have to meet the bureaucratic requirements of public funding. Moreover, their projects need to be adjusted to aims of «polytechnics». Their activities have to be interesting for the re-

[10] Institut for angewandte Forschung (IAF).

[11] At least this was possible in the past. Now it is different for each university.

search areas of the polytechnics and/or offer opportunities to students to doing training on the job or to do the Master Thesis.

Another important aspect of the management model is the limited involvement of the Public Administration in the Steinbeis Model (Ortiz, 2015b). The Steinbeis foundation itself prefers a minimum role by public funds to ensure market orientation. Too much state intervention would prevent the closure of unprofitable Centres due to insufficient demand (STW, 1996, p. 5/6). The foundation works on the basic idea that knowledge and experience should not be given away, rather, the services offered must be paid for, since payment should be an indicator to measure existing demand. Therefore, the foundation and the individual centres deliberately have a low level of provision of state funds (direct financing). In the beginning of its existence the State support was relatively high (40% in 1974) but later on this percentage went down and nowadays is around 2-4% compared with the 22% of the AI. Moreover in the SBC the vast majority of their income is based on firms while in the AI only 52% was based on contract with enterprises[12]. During the creation of new SBCs of Technology Transfer some public support is offered by an initial provision devoted almost exclusively to acquiring equipment and machinery. However, neither the operating costs nor the administrative costs are publicly financed.

SBCs and AI compete with other consultancy service providers. However, as will be explained, they have the advantage of lower overhead costs and a more flexible staff structure. On the one hand they have lower fixed costs because the vast majority of investments in infrastructures and equipment is already paid by the PS&U. Although they pay the use of those installations, probably a part of those investments would not have been profitable, due to a problem of scale effects or critical mass, if they had used it only for their own firms. Secondly, they are more flexible in personal costs than firms for R&D services because they hire personnel of the polytechnics by hours, while the basic salary of a large part of their personal is paid by those PS&U. This fact involves a second – indirect form - of public support generating two important advantages in. In comparison with firms to compete in the market, a large number of staff members of the SBCs are also teaching staff of the PS&U. This means that their basic costs (salaries and social security) are already paid so the SBC and AI have flexible personnel costs and no fixed costs in maintaining their staff in temporary periods with lack of sufficient contracts. Also they do not bear the extraordinary costs of firing their personnel. Both facts (hiring personnel and equipment owned by the PS&U) reduce the risk in starting new An Institutes and SBCs. Researchers do involve themselves without preoccupation about their professional future, because their tenure post and salary are assured. Secondly it requires less financial effort for investments in machinery and equipment –with its corresponding risk- if the investments failed and the acquired infrastructure does not work. In oth-

[12] Data for 2007 for all the AI including those on universities.

er words, a part of the risk-related costs of investments that have been *incurred* already and thus cannot be recovered easily (sunk costs) can be avoided due to its location in the PS&U. Although, it has to be highlighted that the direct costs of the contracts obtained by the SBCs –including the use of infrastructural facilities and materials- has to be paid. Especially in the case of the SBC the experts consider that they charge real market prices. In the case of the «An Institutes» this aspect is not clear and probably will be different for each of them.

2.2.3. ***Evaluation of the role and impact of both models***

Almost no in-depth evaluation studies exist on the impact of both models and therefore it is difficult to offer verifiable facts on their shortcomings and only some indirect remarks can be made[13]. A first critical remark on the functioning of the Steinbeis model is the non-existence of the supposed level of cooperation between the different centres (Ortiz, 2015b), due to the pressure to obtain revenues and a high degree of inter-centre rivalry (Cooke and Morgan 1990/1994). The limited size of the centres makes it difficult to be aware of the activities and expertise of the other 1000 centres and even more difficult is to communicate with them on a regular base. This means that the synergies between the centres are less than could be expected (Ortiz, 2015b). Moreover, Ortiz argued that in terms of the community dimension only to a limited degree do the actors of the SBCs have a commonly shared identity (Ortiz 2015b, p. 13).

Another critical remark is related of the real role of the SB and AI models in its support of the SMEs in general and specifically for the smallest ones in the more traditional low-tech sectors. An early study showed that the supposed support of the Steinbeis Model to SMEs with difficulties to access to most of the policy measures was not clear. Cooke and Morgan (1990/1994) argued that the Steinbeis Model deals especially with innovative firms and the most dynamic SMEs since it only gives help to firms who approach the centres, which means that still an important part of the SMEs is out of the reach for public support.

The specific role of this kind of institutes in the market is another aspect to bear in mind. On the one hand, both models could conflict with the existence of free competitive markets. They compete with the private firms that offer R&D and innovation-related services and there is a debate as to whether they could offer their services at below market prices due to their privileged situation in the polytechnics. Although the experts do highlight that SBCs are charging real market prices. Since the introduction of the «Separation Calculation» according to the EU Community framework for state aid for research, development and innovation, which came into force on 1 January 2007, all universities and related institutes have to charge market

[13] Some of them are form outdated studies and their present reliability is assumed although it cannot always be proven with clear facts.

prices. However, as mentioned, the risk and overhead costs and stable situation of their employees as lecturer and researcher in the PS&U make it easier to create SBC or AI than a real private firm.

Another debate is related to the fact that the evaluation of PS&U included as criteria the income of third mission. In recent years the PS&U received increasing autonomy in combination with the pressure to initiate a more in-depth approach to the market. This new tendency generated a discussion of the desirability of the independence of the SBCs and especially the «An-Institutes». Nowadays the «third mission income» is used as an important indicator for evaluation of the PS&U. The budgets of the IA and SBC are not included as third mission activities in the budget of the PS&U generating a negative impact on the evaluation results of the PS&U (Koschatzky *et al.*, 2008).

A further aspect that requires attention and an in-depth analysis is the very small size of the SBCs and «An-Institutes» in relation to their portfolio of services. Both «organisations» consist of a broad number of specialised small independent units (6-8 employees) in every broad spectrum of research areas and expertise. In fact, most of them are much smaller. In the case of the SBC the average of 8 persons by head count would be reduced clearly if you could use the real number in «Full Time Equivalent» because a large part of them are (often part-time) researchers or students. Moreover, the size of 80% of the SBC is very small because only 20% of its units generate approximately 80% of the total turnover, creating an imbalanced and fragmented structure o (Ortiz, 2015b, P14)[14]. In other words, around 800 of the 1000 SBC are very small however. Taking into account the big differences between the size of the «An- Institutes» we could expect a similar situation although we have no specific empirical data to prove this normative statement. Anyhow, Ortiz argues that the smaller units also have a clear role as actors in the regional innovation because they fulfil the needs which are proved to exist by the obtained market based contracts.

2.3. **Critical success factors of the Steinbeis model and «An-Institutes» versus its transferability to other countries**

Despite the fact that Germany is well known for its evaluation culture carrying out impact evaluation for a high percentage of the policy programmes (Delanghe *et al.*, 2011) the SBCs and «An-Institutes were scarcely evaluated in the past. No in-depth evaluation studies were detected that analysed their impact in the firms or regions. The mere existence and permanence of the traditional models over a long period, together with the existence and survival of over 1600 centres or institutes and the increase of their budgets received from the market justify their role in the regional innovation landscape. Especially was this true in the case of the SBCs whose

[14] Therefore, the SBC is at this moment involved in a reform process to reorganise its activities (Ortiz, 2015b).

very fast growth was achieved without almost any public support. However, it will not be easy to apply the explained models in innovation systems of countries with a less successful economic model and less developed innovation systems.

Several critical success factors can be mentioned to explain the success of the Steinbeis model and the «An-Institutes». One of the most important success factors –which make it difficult to imitate the model in other countries- is the professionalism and market orientation shown by teachers and researchers of the «Fachhochschulen». To apply for a job in such schools a five -year' business experience with a certain level of responsibility in technological activities is required. This means that all staff members of the polytechnics have entrepreneurial culture or at least speak «the businessman's language». Moreover, this entrepreneurial culture is updated constantly due to the feedback based on a continuous interaction with the business sector as tutors and directors of graduate dissertations, as supervisors for the students that do «on the job training» programs or apprenticeships; during the interaction with «students» of the long life learning programs and/or specialised training for businessmen with experience and last but not least due to their participation in (cooperative) research contracts. In other words, all these forms of interaction created a mutual learning process and permit the teaching staff of the PS&U to update their own experience and expertise. They have permanent interaction with the enterprises due to the study track of their students. Those are working on real applied research activities as assistants in the research projects of the SBCs or «An-Institutes» and/or by their graduation projects carried out in the firm on real problems. On the other hand, an inflow of technological capabilities and entrepreneurial attitude is generated by the integration of private sector businessmen or workers with wide experience as part time consultants in SBCs. To conclude, the SBCs have a market orientation based on the experience and skills of their directors or managers. In fact, the selection of the directors of SBC is based on their reputation, business skills and creativity (Cooke and Morgan, 1990). In Spain this is not the case and a large part of the staff never worked directly for a firm. This does not mean that the students have a low level of training, though their knowledge is very theoretical. A Dutch head hunter in Spain looking for engineers for the Dutch firms highlighted that Spanish engineers have a good basic knowledge, which make them very compatible with the Dutch engineers, who are very good in creative aspects and group work but lack a theoretical base.

A second critical success factor that assures the success of both models –and which makes it difficult to copy the model- is the difference of the German economic growth model based on the potential of their innovation system. The advanced technological position situation of several German regions (Baden-Württemberg, Bayern, North-Rhine Westphalia, etc…) and of Germany as a whole implies that their firms have a clearly better absorptive capacity for and access to external innovation than in the case of Spanish enterprises.

A last important success factor of both types of institutes is regional proximity. The IA and SBS can be considered as an instrument of regional policy due to their orientation towards future technologies of regional significance and –very important- their proximity and their image as reliable partner often based on a long-term relationship as providers for innovation to regional firms. On one hand the PS&U are regionally spread while the SBCs are endowed with the creation of Mobile Centres for areas where there are no polytechnics. In fact, the clients for both types of centres are generally SMEs geographically close to the polytechnics.

3. NEW INSTRUMENTS FOR PUBLIC PRIVATE TECHNOLOGY TRANSFER: «RESEARCH CAMPUS - PARTNERSHIPS FOR INNOVATIONS»

3.1. Background of the instrument

The more traditional models of technology transfer are based on the use of existing experience of PS&U. However, as we mentioned, these models are based on a mostly passive approach where the firms look for expertise offered by the SBC or IA, and probably, as just argued, they do not match the future demand (Ortiz, 2015a). Therefore, some new models were developed in the last years focused, among other matters, on the active creation of experience and expertise in new relevant emerging sectors.

In addition to the traditional transfer instruments between science and industry, such as direct contractual cooperation or framework agreements, further forms of cooperation between universities, companies and non-university research organisations have been established in Germany and other countries since around 2010. Industry on Campus concepts are a special form of cooperation between universities and industry (Wissenschaftsrat 2007: p. 37). Originally developed in the United States (e.g. the University Industry Research Centres), this model is increasingly being applied in Europe. Large and multinational enterprises in particular have invested in the development of joint R&D capacities with universities and have developed joint research centres and laboratories. Cooperation with a higher education institution is an essential factor in attracting global R&D investment and can be supported by public funding as well as the university management (Koschatzky 2013).

This development is driven by the increasing flexibility of the scientific and research policy framework conditions and the need of companies to collaborate in innovation projects with other organisations. On the part of the higher education institutions, the increasing degrees of freedom and autonomy that public research organisations have experienced in recent years (for example in the context of new public management principles), increased transfer expectations at universities and the handling of exploitation rights can be seen as driving factors (Koschatzky *et al.* 2014). Moreover, in the field of public administration and politics, the willingness to enter into new forms of partnerships has increased as a result of cuts in public budgets.

3.2. **How is the model organised and for which agents does it work?**

The funding initiative «Research Campus - Partnerships for Innovations» by the German Federal Ministry for Education and Research (BMBF) is an example of public funding for long-term public-private research and transfer partnerships. In 2011, the BMBF published a guideline on «Research Campus», in which initiatives and networks of universities, companies and other research organisations were invited to apply. More than 90 applications were received. In September 2012, an independent jury selected 10 research campus models for further funding, nine of which are currently (2018) active. In the following, the respective universities and corresponding research campuses are listed (BMBF 2014; Koschatzky 2017: p. 8). See also Figure 1 for the regional distribution:

- RWTH Aachen: Digital Photonic Production (DPP) and Electric Networks of the Future (FEN)
- Free University Berlin: Mathematical Optimization and Data Analysis Laboratory (Modal AG)
- Technical University Berlin: EUREF - Mobility2Grid
- Jena University: InfectoGnostics
- Magdeburg University: Stimulate - Solution Centre for Image Guided Local Therapies
- Mannheim and Heidelberg University: Mannheim Molecular Intervention Environment (M2OLIE)
- Stuttgart University: ARENA2036 - Active Research Environment for the Next Generation of Automobiles
- Wolfsburg/Technical University Brunswick: Open Hybrid LabFactory (OHLF).

The funding programme «Research Campus» has three distinct characteristics:

- A mandatory public-private partnership on «equal footing»
- The medium- to long-term adaptation of a specific research topic, ideally within a research programme
- Proximity - the bundling of research activities and competencies at one location, as possible on a university campus.

The objective of «Research Campus» is to promote cooperation between partners from science and industry by combining resources for pre-competitive basic research in forward-looking research and technology fields in the form of public-private partnerships located on the campus of a university or research institute. A maximum of two million Euros is available per research campus per year in the form of grants. The duration of the funding initiative is set to run for 15 years, al-

though funding for individual research campuses may be shorter. In addition, the partners are expected to make significant financial and in-kind contributions of their own in order to achieve the greatest possible leverage from public funding. With the «Research Campus» Initiative, a new model in the transfer system has developed in Germany that unites the research strengths of universities, the application orientation of non-university research organisations and the market orientation of the participating companies by the establishment of new transfer bridges and modes of transfer (cf. Koschatzky and Stahlecker 2016).

Figure 1. **REGIONAL DISTRIBUTION OF THE RESEARCH CAMPUSES**

Source: own draft.

3.3. Main critical success factors and constraints / requirements for implementation in other countries

In relation to the three distinct characteristics of the «Research Campus» funding initiative, a research project conducted by Fraunhofer ISI has yielded the following results.[15]

3.3.1. Binding partnership between science and industry

Research campuses are a legally binding partnership between science and industry on the basis of contractually regulated relationships and long-term ties. In the research campus, SMEs as well as large companies, universities and non-university research organisations work together. The number of partner organisations in the research campuses varies between 12 and 35, with an average of 20 companies and research institutes making up a research campus. SMEs dominate (average of eight per research campus), closely followed by large enterprises (average of seven). On average, three non-university research institutes and two universities are partners from the science system. Examples of non-university research institutes are the Konrad Zuse Institute Berlin, industry-financed university institutes such as the E.ON Energy Research Centre in Aachen, several institutes of the Fraunhofer-Gesellschaft as well as the Leibniz Association and the German Aerospace Centre.

In terms of staff, the research campuses reach the size of a medium-sized research institute. On average, just under 31 people (full-time equivalents - FTEs) per research campus work in the projects funded by the BMBF. Additionally, nearly 23 further FTEs are financed from the own resources of the research campus partners.

The partnerships are based on trustful relationships. In this context, the regulation of decision-making rights and funding contributions, the management of intellectual property rights and the exploitation of research results are central issues. The aim was to agree on solutions «on an equal footing» in order to achieve a balanced consideration of the interests of industry and science. Equal footing is considered to be important and decisive for success by all partners. However, depending on the specific constellations, it is implemented flexibly in order to avoid conflict situations without disadvantages for individual partners (e.g. through context-related regulations on intellectual property rights). Examples of this are that industrial property rights are registered either locally by the inventors involved in the projects, by central industrial partners or by the university. There are cases in which the inventors apply for an industrial property right, but the research campus has a pre-emptive right of first refusal.

Within a research campus, knowledge flows openly between the partners, even though it is regulated by confidentiality agreements. The aim is to generate innova-

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[15] See Koschatzky *et al.* (2016) for more details.

tion in new (technological) fields in order to create new markets and applications. Research campuses are regarded as a platform for defining new bilateral or multilateral projects, which can be carried out in or outside the campus. In this respect, open innovation is a general principle within the campus (Chesbrough *et al.* 2006). On the other hand, it is a protected space because this kind of collaboration is based on trustful, sometimes long-existing relationships between the partners. These relationships have to prove their stability and sustainability within this new form of cooperation. Therefore, there is an inherent tendency, at least during the start-up phase, to focus on the stabilisation of the existing network and not to open it up too quickly to other organisations, especially possible competitors.

For companies, the involvement in a research campus is not the only, albeit far-reaching, option for cooperation and transfer. Participation in a research campus is part of a series of different cooperation and transfer activities with external partners, especially for larger companies. In some cases, companies have similar strategies for collaborating with employees of other companies and research institutions in accordance with the «under one roof» principle or for sending employees to partners. The parallel participation in a research campus emphasizes the testing of a new type of common research structures and the search of companies for new ways of research cooperation.

3.3.2. ***Long-term orientation and proximity***

An essential feature of the «Research Campus» funding initiative is the long-term nature of the cooperation. This long-term approach creates a stable framework for the development of sustainable structures, for example through sufficient payback periods for investments in research infrastructure (e. g. new buildings). It is therefore a matter of reliability to be able to tackle long-term strategic projects that would be much more difficult to implement with a shorter time perspective. This influences the thematic orientation of the research campuses by enabling them to address complex, interdisciplinary and innovative topics that initially have a high degree of uncertainty and whose application potential will only become apparent after a few years.

Spatial proximity within a research campus is mandatory and sometime, plays a role, but is not always necessary. Regional or social proximity between the partners in a collaborative network matters, especially in early phases of the cooperation experience and research activities. In cases where distinct centres are established it is more a technical characteristic that partners are located close by. Personnel from the companies is not always present in the labs, because these researchers have to maintain the link with the research department in their company through weekly personal visits.

Doctoral students are the main focus of the research staff at the research institutes, but companies also send their own doctoral students to the research campus.

This reveals an important complementary goal of the research campuses: education and training as well as qualification. Extensive activities can be observed in this area. New study courses and doctoral programmes are being developed at several universities in the context of the research campus (e. g. bachelor's and master's degree programmes in medical technology in Magdeburg or doctoral programmes in Brunswick and Mannheim). Research training groups, summer schools, an international student programme and lectures are further examples. PhD students from universities and companies work on their scientific qualification in the research campus. They acquire knowledge in applied projects and project management, gain an impression of what is required from universities or companies and thus acquire important additional qualifications. Thus, doctoral students and scientists both in science and industry qualify for a change of sides. In addition, further education and training programmes in the topics and technologies in which the research campuses operate are designed and offered.

In these activities, a special role of the research campuses at the interface between knowledge and technology transfer and vocational education and training becomes apparent. Research campuses offer universities special freedom for research and teaching by providing a research infrastructure that is not otherwise available in 'normal' university research. For this reason, the research campus is also associated in individual cases with particularly positive effects on teaching and research, in particular due to its long-term nature and technological equipment. In these cases, however, jealousy and competitive situations can arise because the research campus ties up funds and personnel capacities of the university which are not available for other activities. Another aspect in this context are critical voices from disciplines far away from industry that deplore the proximity and dependence of research work on industry in the research campus, thus jeopardizing the freedom of research (Koschatzky 2015: 26).

The research campus is part of comparable international activities to support the transfer of knowledge and technology and to reorganize the cooperation between science and industry. These include the Industry/University Cooperative Research Centers in the USA, the Cooperative Research Centers in Australia, the VINN Excellence Centers in Sweden and the COMET (Competence Centers for Excellent Technologies) in Austria. These programmes and activities differ according to their objectives and structures reflecting the institutional specifies of each country. In this respect, «Research Campus» is somehow unique with regard to the long-term perspective of up to fifteen years, the freedom with regard to the regulation of the organisational structure and the intellectual property rights on «an equal footing», and the demand to organise the research collaboration in spatial proximity between the partners on a campus of a university or research institute. On the other hand, other aspects like the necessity of monitoring and evaluation are something which applies to models in all countries.

3.3.3. Transferability of the model

Strategic research partnerships like «Research Campus» are a «high-end» in transfer activities from higher education institutions. This is not only the case for Germany, but for all other countries in which this kind of partnership programme is implemented. Research Campuses as such might be difficult to transfer to other countries and regions, because it strongly depends on the German national institutional framework with regard to technology and innovation policy, other transfer programmes, and experiences acquired over decades in research collaboration between universities and industrial companies. Many of the networks which constitute the different research campus models rely on already existing cooperation experiences in other contexts. Trust between the partners, maybe not between all, but certainly between core actors, is an essential basis for agreeing on a long-term partnership in a technological field which is characterized by high uncertainty. Nevertheless, as similar programmes in countries like Austria, Sweden, Australia, or the USA show, public private partnerships in research and innovation can be an option for the improvement of transfer linkages between universities, polytechnic schools and firms.

3.4. **Level of success and measurement**

The establishment phase of the individual research campuses was supported by an accompanying research between 2012 and 2016.[16] The information collected during this period provided an insight into the first developments. As some of the research campuses did not start their work until 2014 or 2015, the accompanying research does not permit a measurement of success or an evaluation of individual research campuses or the entire programme. An evaluation is planned on the part of the BMBF, but has not yet been advertised at the time of writing this contribution.

Among critical success factors are the achievement of scientific objectives, the successful handling and implementation of the agreed regulations with regard to information flows and the handling of intellectual property rights. It also includes stability and openness of networks (e.g. with regard to the integration of international partners), scientific output with regard to publications and successfully completed dissertations, patent applications, business start-ups, international visibility and scientific excellence.

Regarding the scientific and technical output, extensive activities were visible until the end of 2015. In 2015, more than 200 new publications were created in the research campuses. The first patents (total of ten until 2015) have been applied for, but not by all research campuses. The number of invention reports is somewhat higher. Due to the short period of time since the start of the activities of the research

[16] See Koschatzky *et al.* (2016).

campuses and thus possible patent applications, no license revenues have been recorded yet. However, in some of the research campuses, project results have already been exploited within or outside the research campus as part of further activities.

All in all, the participating companies and research institutes rated the «Research Campus» model as positive for the first years of funding. Within the nine research campuses, a common identity has developed under the umbrella of the research campus. The criterion of cooperation «under one roof» has proven its worth and is regarded by the partners as decisive for success. Knowledge exchange, transfer and contacts would perhaps not otherwise have been possible. From the company's point of view, there are clear advantages to be gained from the commitment to the research campus. In 2015 alone, more than 45 new projects worth over EUR 10 million were launched. In addition, the vast majority of the research campuses shape the location and have a strategic added value for the participating universities, because they send out a positive signal for the transfer between science and industry.

4. **FINAL REMARKS**

As could be observed in this text, the German model of technology transfer from the educational system is clearly focused on the integration of the educational role and the usefulness of public research in the production sector. The dual approach in education is a must not only for polytechnic schools but also at 1university level the practical application of the acquired knowledge is part of the study plans. Especially in the case of the «An- Institutes» and the Research Campus initiative a basic requirement or objective is its educational characteristic based on the involvement of (PhD) students and further vocational qualification in the handling of new technologies. Both universities or PS&U and firms are jointly engaged in these training and qualification activities.

It is also made clear that part of the success of the German technology transfer model depends on the very dynamic and innovation context of the German economy with a significant presence of innovative SMEs and multinationals. Moreover, this is completed with a high level of integration of the educational-scientific-business system. The implementation of such models in countries -like Spain- requires an adaptation. In the case of Spain, it requires the involvement of several public agents and ministries and a long-term policy with complementary measures. For example, the creation of incentives to teachers to make approaches to the world of business, adapt the process of selection of teaching staff and their promotion mechanism to (regional business) needs and introduce in the study plans the obligation of work experience for students[17].

[17] For example, in form of apprenticeships and during the development of their graduate thesis.

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