Inside View of a Technology Transfer Office – A Benchmark Perspective

Bernhard Smandek, Andreas Barthel

PTB Physikalisch-Technische Bundesanstalt, Div. Q - Scientific-technical Cross-sectional Tasks

Abstract

PTB is the national metrology institute of Germany. Based on German law and in accordance with European Commission (EC) recommendations PTB has been pursuing technology transfer for more than a decade. Our overall objective focuses on macroeconomic benefits, especially for small and medium-sized enterprises (SME) as they are the ones creating an above average number of workplaces. The underlying strategy is "organic growth" facilitated by the technology transfer office (TTO). The most important transfer scheme involves interaction with the research departments of PTB and with industry, i.e. SMEs. Intellectual Property (IP) rights play an important part in structuring technology transfer. For IP management a Balanced Scorecard (BSC) approach was developed. As a conclusion - due to the highly skewed income distribution - royalties from licensing play a welcomed, but minor aspect of the innovation activities of the institution. Comparing our technology transfer approach with key indicator figures (KIF) of pan-European surveys places this TTO very well in the middle of the field. Conclusions on success factors and operating schemes for TTOs may be drawn.

Keywords

Technology transfer, innovation system, intellectual property, licensing, good governance

1 Introduction

Decentralized technology transfer and patenting have been pursued by PTB since the late 1990s. A decade ago, additionally to technology transfer at the research department level, PTB established a Technology Transfer Office (TTO) in 2004 as part of its cross-sectional tasks. In this paper we debate the overall tasks of a public institution to foster innovation with underlying questions arising such as the following ones. What are the best routes to support SME? Which role does IP play in the process? What are the operational rules and guidelines in IP management? How does this relate to pertinent laws and European Commission (EC) recommendations? What are the expectation values for key indicator figures (KIF) for a "normal" TTO? Which role do royalties play?

2 Innovation systems

Innovation is a driving force for new economic developments, job creation, wealth and for the public benefit in general. The European Union has identified several societal challenges for the future, among others: climate change and resource efficiency; secure, clean energy; advancement of health and innovative and reflective societies. In its flagship initiative "Innovation Union" the European Commission states, that

> *"perhaps the biggest challenge…is to adopt a much more strategic approach to innovation(…), whereby innovation is the overarching policy objective(…) where we take a medium- to longer-term perspective(…)"(EC, 2010).*

Nowadays intangible assets of companies constitute a substantial portion of their market value. This does not only hold for the obvious cases of pharmaceutical, communication or software industries, but is a widespread phenomenon. To name just one example, intangible assets comprise 73 % of the value of S&P 500 companies (Mittelstaedt, 2009).

Universities and public research institutes in OECD countries absorb almost 40 % of the overall national efforts for research and development (R&D), overwhelmingly originating from public channels (Abramson, 1997). To transfer this knowledge to fulfill societal needs, mechanisms are sought for which are commonly referred to as "innovation systems". This is in contrast to the more linear schemes, where academia publishes and the private sector picks up the results of interest. On the contrary, the innovation system approach stresses

> *that the flow of technology and information among people, enterprises and institutions is key to an innovative process (OECD, 1997).*

Within academia different aspects of this process have been addressed. "Science marketing" is more concerned with offering know-how from the university side, the "entrepreneurial university" considers itself as a business partner for companies and IP management is sometimes optimistically considered as a source of additional income when public funding is tight.

By the mid-1990s it became increasingly accepted that understanding and nurturing an innovation system is a complicated, intertwined process with three main actors:

- the government to set policy standards and to supply funding
- academia, where technology transfer is viewed as a "third task" next to research and education and
- companies as the targets of knowledge transfer, which must have the required absorptive capacity.

Lent by biochemistry, a heuristic visualization of this entangled process, the “triple helix” concept, is depicted in Figure 1. The concept was introduced in the 1990s (Leydesdorff, 1998), now has a Stanford-based concept group (Stanford, 2014) and celebrated its 13th Annual Congress last summer (Triple Helix, 2013). Figure 1 paraphrases the aforementioned three main actors, which have mutual interaction along the innovation path, upwards on the vertical axis. The connections between the continuous strands are viewed as erratic, fuzzy and even sometimes chaotic. Societal needs are at the foundation and initialize the process (Leydesdorff, 2003).

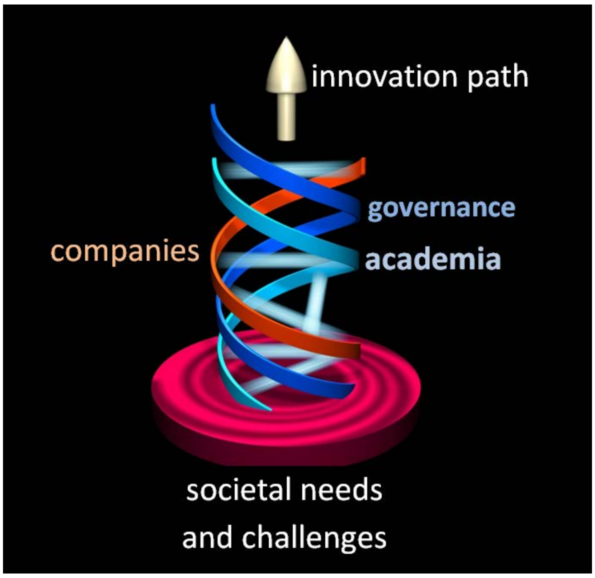

Fig. 1: Triple-helix innovation: Each helical strand follows its own path according to its internal regulation, but with a common goal. Interactions along the process do not follow a simple linear scheme, but are rather mutually intertwined.

Good governance supplies adequate funding, in particular to SMEs to cross the “valley of death”, in which classical market failure occurs. The connotation “valley” refers to the technology funding gap between a “proof of principle” in a science laboratory and all the work and expertise necessary to create a first functional prototype and eventually result in a marketable product or service. To bridge this gap, a variety of public funding schemes are available. For example, the ZIM programme in Germany supports pre-competitive research for SME collaboration with academia with an annual budget of € 500 million. More than 10 000 projects have been funded since its advent in 2002 (ZIM, 2014). Other programmes target specific technology fields or pre-normative development by other federal support schemes (PTB, 2014). In the world of European national metrology institutes, a sub-programme of Horizon 2020 with a € 600 million budget was initiated. This consists of a §185 measure which requires 50-50 funding through the EU and its member states. This European Metrology Programme for Innovation and Research (EMPIR) opened its first calls for industry-related research early in 2014 (EURAMET, 2014).

Within the academia strand of Figure 1, PTB has established close relations to industry for years, as precise measurement is at the heart of quality inspection and quality infrastructure. Technology transfer is pursued at the research department level by using the programmes named in the above paragraph. A central office gives advice and coordinates activities along the internal value chain of our research results.

3 Public tasks of PTB

PTB is the National Metrology Institute of Germany, an agency of the Federal Ministry for Economic Affairs and Energy (BMWi). As a national metrology institute it is obliged to “define, disseminate and to improve the relevant measurement processes” for the physico-technical fundamental international unit system (SI units) (BMJ, 2014a). These are the meter, the second, the kilogram, the ampere, the kelvin, the mol and the candela. Through technical comparisons of national standards for these units with those of other countries, a distinctively defined international measurement system of high accuracy is created. The economic impact can be felt virtually in every sector of the economy, from international trade, supply chain management, energy grid synchronization, cellular phone communication all the way to satellite navigation. The major macroeconomic impacts of a well-defined unit system are lower transaction costs and improved production efficiency.

To increase the accuracy of the international scale of units, PTB allocates about 60 % of its budget to fundamental and applied research. Single electron transistors, small-scale optical clocks and lithographic nanometre samples are some examples of spillovers from our metrological research that are of high relevance for the electronics, aerospace or semiconductor industries. The other 40 % of the budget supports calibration services, legal metrology, including consumer protection, and national and international quality infrastructure. Key data on PTB and on the routes of technology transfer are summarized in Table 1.

Gross figures	
Number of full time employees (FTE)	1932
Budget	€183 million
Knowledge transfer	
Publications	606
Technology transfer	
Participation within standard setting organizations (SDO)	534
Direct R&D, with industry participation	Typically 100 projects at any point in time
European projects for fundamental and applied research, with industry participation	Typically 80 projects at any point in time
Total patents or patent applications	133
Inventions per year	25

Tab. 1: PTB data on knowledge and technology transfer (2012).

Table 1 already indicates a hierarchy of knowledge and technology transfer mechanisms. Publications and standards are at the top, industry-driven R&D projects at the second level and the transfer of IP is an additional feature. Spin-offs are sporadically of high importance. But due to the highly specialized niche markets addressed in direct transfer activities, the rate of spin-off company foundation is very low.

4 Balanced approach

With a strong impetus on legal tasks and market neutrality PTB considers technology transfer as a further aspect of the dissemination of the SI unit system by creating novel instrumentation and inspection devices. Therefore, its mission statement on technology transfer labels R&D cooperations, support of spin-offs, personal exchanges and IP-rights on an equal footing as tools within this innovation system (PTB, 2005).

While cooperations at a scientific level are mainly decentralized in the departments, the management of IP is regulated by the central TTO. IP is understood in the broadest sense as any item with an economic value available for licensing. This might be copyright protected items like computer programs or part lists as well as inventions and patents. The actual patenting is done by external lawyers under the auspices of the legal matters section. Early on in PTB´s technology transfer history a concept to integrate this technology transfer activity with overall market neutrality and legal tasks was developed (Gahrens, 1998).

In 2008 the European Commission published a “recommendation on the management of intellectual property” as a “Code of Practice for universities and other public research organisations” (EC, 2008). It was noticed, that

> *Public research organizations need to disseminate and to more effectively exploit publicly-funded research results with a view to translating them into new products and services…*

To effectively exploit publicly-funded research results, a two-sided process has been proposed, that is to

> *Promote the broadest dissemination…by…encouraging open access…, while enabling, where appropriate, the related intellectual property to be protected* - and to - *introduce national guidelines…concerning the management of intellectual property…*

The subsequently proposed Code of Practice names the following numbered items for an IP management tool box:

- › Develop an IP policy (1)
- › Set clear rules for staff (2) and provide incentives (5)
- › Promote identification and exploitation (3) and

› Take a portfolio view of IP (5)

In its section on the underlying principles (9) it states explicitly, with KT refering to knowledge transfer:

> *While proactive IP/KT policy may generate additional revenues for the public research organization, this should not be considered the prime objective.*

In its IP management system PTB has taken a balanced view by introducing a Balanced Scorecard Approach (Smandek, 2011), abbreviated to BSC. Viewing business processes from different "perspectives" is one of the fundamental ideas. The different perspectives by which PTB observes IP management are shown in Figure 2.

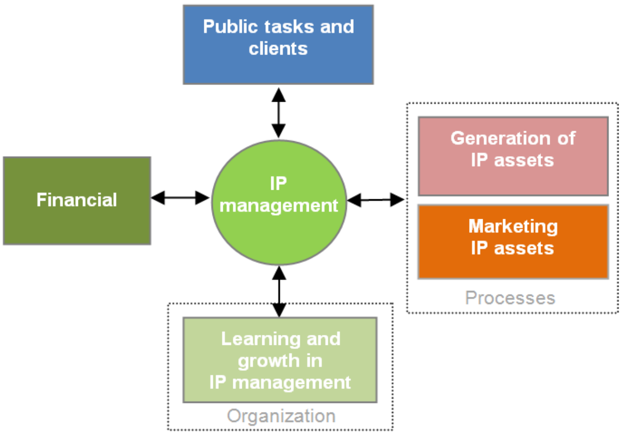

Fig. 2: Balanced Scorecard approach to IP management at PTB. The basic idea is to view a complex management problem from four different perspectives. Thereby, conflicting requirements can be partially reconciled. Note that in contrast to the original work (Kaplan, 1996), not finances but public tasks hold the top position.

To formulate a balanced scorecard there must be first and foremost an underlying strategy. Then benchmarks for the perspectives of Figure 2 are set with respect to goals and actual resources. For example, a high patenting rate serves scientists and the institution as an incentive, because it will elevate their reputation. This however keeps the TTO staff busy with patents, not with licensing. Additionally patents are associated with high costs and may jeopardize the net income of the institution. Vice versa, too low a patenting rate will lower motivation and results in a pool of possible high flyers, which is much too small.

5 IP management – underlying aspects

PTB considers IP licensing as an additional tool to transfer valuable knowledge, developed through R&D. Looking at the right-hand box of Figure 2, "Generation of IP Assets", the questions of assisting possible inventors through the TTO and that of patent ownership arise. Ownership by PTB of non-patent IP is automatically given through the normal work contract. For employee inventions PTB claims ownership of inventions, which possess a monetary value for the following reasons:

› Avoiding conflict of interest for the employee, as many inventions will be used in our laboratory or in subsequent PTB projects for functional prototype development with a company (described earlier in paragraph 2)
› Protecting PTB´s own IP when engaging in contract negotiations
› Having the freedom to operate (FTO) as an institution with respect to third parties
› Performing technology transfer according to a clear and publicized set of rules
› Covering patenting costs and generating income

Having set this as an in-house policy, two comments are necessary.

Firstly, the TTO does not operate as an outside agency apart from the inventor. On the contrary, based on our own experience and on the literature (Agrawal, 2006), the inventor is the key lead for licensing success. One incentive are novel projects for the department if the invention requires functional prototype development. This is most often the case. If the resulting prototype can be transferred, the inventor receives 30 % of the royalties from licensing as a personal incentive.

Secondly, a deviating approach to the university ownership of a patent, i.e. handing it over to the inventor, was taken recently by the EU-member state Poland (WIPO, 2013). A "Bayh-Dole type" approach was questioned earlier by Movery et al., stating that patenting and licensing only constitutes 9.5 % of technology transfer activity (Movery, 2005). In our opinion this is indeed the case as previously shown in Table 1. But this does not contradict the mere fact that proper ownership for an institution must be set if an employee's invention is to be used in the laboratory. The EC guidelines of paragraph 4 appear to be a better approach.

In summary, if FTO for the institution is to be realized, transparent public rules for IP dissemination applied and internal conflicts of interests avoided, a public ownership of employee's inventions, the "Bayh-Dole type approach", is still the best reference point.

Looking again at the right-hand box of Figure 2, "Marketing IP" refers almost to a private business type approach with investments in the TTO and "return of investment" from royalty income. The PTB patent portfolio is shown in Figure 3. While negotiating with a company, PTB operates as a market participant. Federal Budget Law requires that assets, among them IP, must be sold at the pertinent market prices (BMJ, 2014b).

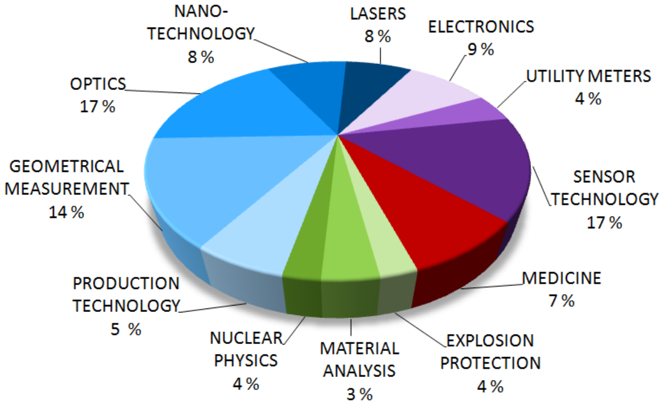

Fig. 3: Patent portfolio of PTB with a focus on engineering. There is only a small fraction of bio-tech and ICT that are known to carry most of the royalties from public R&D (Arundel, 2012; Verspagen, 2006).

From the onset, PTB engaged in an IP management strategy of “organic growth”. Investments in the TTO are kept synchronized with the achieved gains within this business field. In contrast to this, a “venture capital” type approach would pursue high investment with a high risk – high gain profile. Our organic growth approach results from three reflections:

(1) Research patents are at a very early stage of development with market prices several orders of magnitude below those realized in the private sector and those for developed technologies.

(2) We own a portfolio with a very low percentage of medical, not to say bio-tech patents, known to be the front runners in licensing income (Arundel, 2012; Verspagen, 2006).

(3) Despite its huge macroeconomic impact explained in section 3, in direct technology transfer to industry, metrology addresses mainly niche markets of high-end products with extreme measurement accuracy but often small sale volumes.

The resulting activity data are given in the next paragraph.

6 IP management – experience and data

With this underlying organic growth strategy and a Balanced Scorecard approach, internal benchmarks for a few key indicator figures (KIF) are set. The most important ones are

› Number of new inventions - closely monitored on a monthly basis

› Number of industry-driven research projects with direct potential for licensing
› Fraction of inventions, that are claimed by the institution, which are eventually turned into patents
› Forecast for the number of licences within a year and forecast for royalty income

The fraction of "inventions claimed" divided by "all of the inventions reported" is vital for a rigorous portfolio management. This ratio is shown in Figure 4. It is a still picture of a dynamic process: new inventions are registered in the current year on the right-hand side of the diagram. The two green lines set a benchmark corridor for acceptance, which has at the beginning a high value of 60 %. That is, the inventor is assured, that his invention will be valued by the TTO, as long as it is scientifically sound and shows an economic potential. Going to the left and into the past, older patents are re-evaluated. The green benchmark line drops after eight years and eventually levels off close to the 20 % grey line. This limit is the average licensing ratio, which is about 20 % of all reported inventions and more than 40 % of all patents or patent applications (claimed inventions) of PTB.

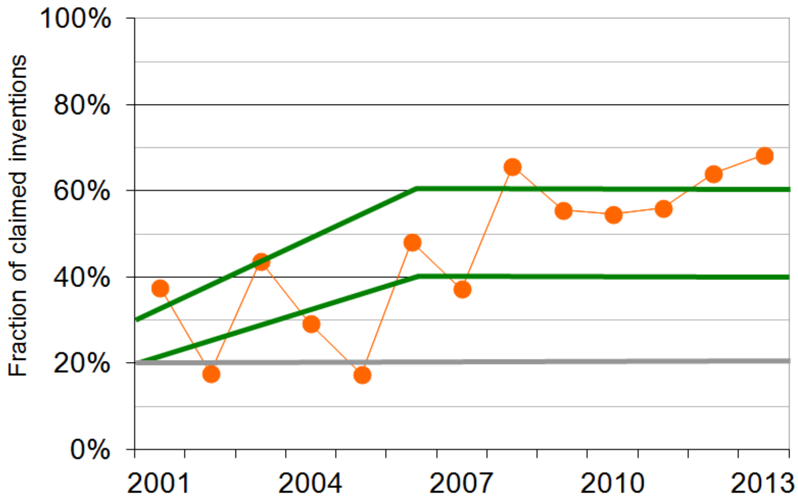

Fig. 4: Acceptance ratio of TTO defined by "inventions claimed by PTB as property" divided by "total number of all submitted inventions". The green lines are benchmarks for the upper and lower limits. Above the upper limit too many inventions are patented, which downgrades cost management. Below the green line too few new inventions fill up the portfolio. Looking back over ten years, almost all inventions have been licensed (grey line at 20 % mark) or returned to the inventor.

The build-up of the portfolio is displayed in Figure 5. What is plotted are the total number of inventions and licences for the pertinent year. The solid lines are polynomial fits to guide the eye. In the build-up phase of the portfolio, there is still an increase of the total number of patents, and patent applications as marketing processes take several years. Starting with 2010 a leveling off occurs. Older patents are sorted out, explained in Figure 4. Approximately the same number of new ones are taken into the portfolio.

Having reached an equilibrium of patent numbers at about 150, the number of licences is still increasing, but at a lower rate. Even though a typical increase of eight contracts per year occurs, there are also some cancellations for older contracts. The inset shows the patent distribution by country. For cost effectiveness Patent Cooperation Treaty (PCT) processes are only transferred to nationalization, if there is a good chance of licensing.

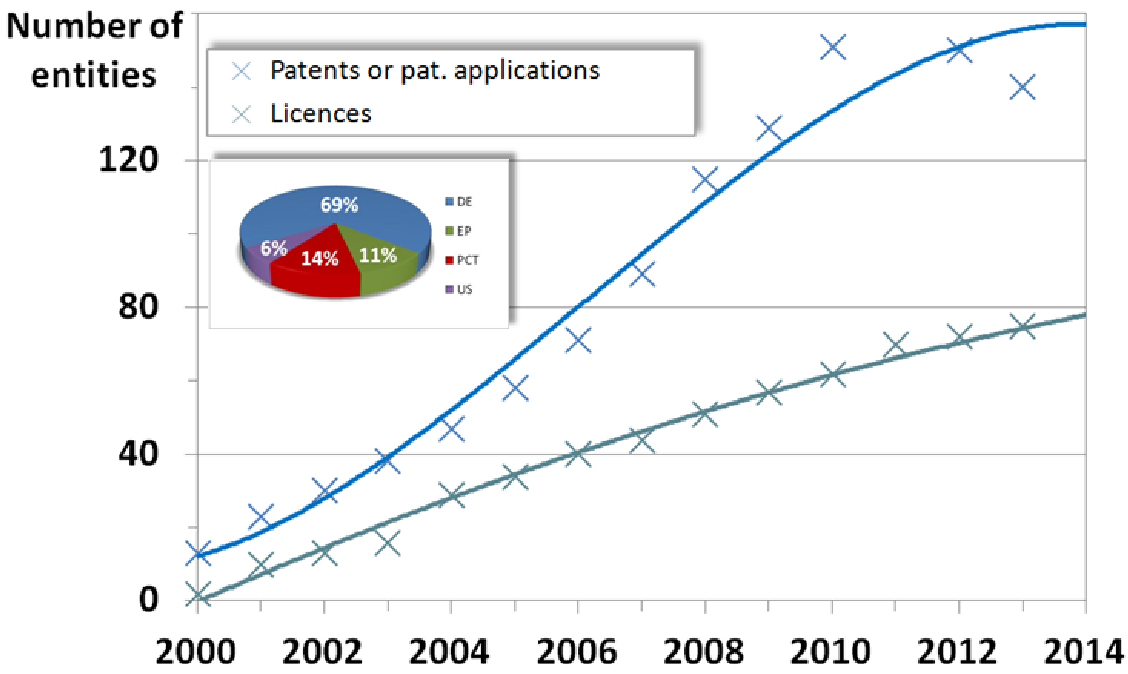

Fig. 5: Total number of patents or patent applications (blue) and licensing contracts (turquoise). In 2010 an equilibrium for the patents occurs, as older ones with little value are discarded. The inset shows the portion of national and international applications. Contracts increase by about 8 contracts per year.

When observing external costs and royalties in Figure 6, it is noteworthy that costs between 2006 and 2010 only increased by 50 %. In the same period the number of patent applications of Figure 5 rose by 100 %. Cost control was first and foremost achieved by licensing whereby the licensee often carried patent costs. Then only a small fraction of international patents was part of the portfolio, depicted in the inset of Figure 5. If there is no potential licensee, the PCT phase is rarely transferred into national patents. Finally sorting out older patents keeps costs low as well, see Figure 4.

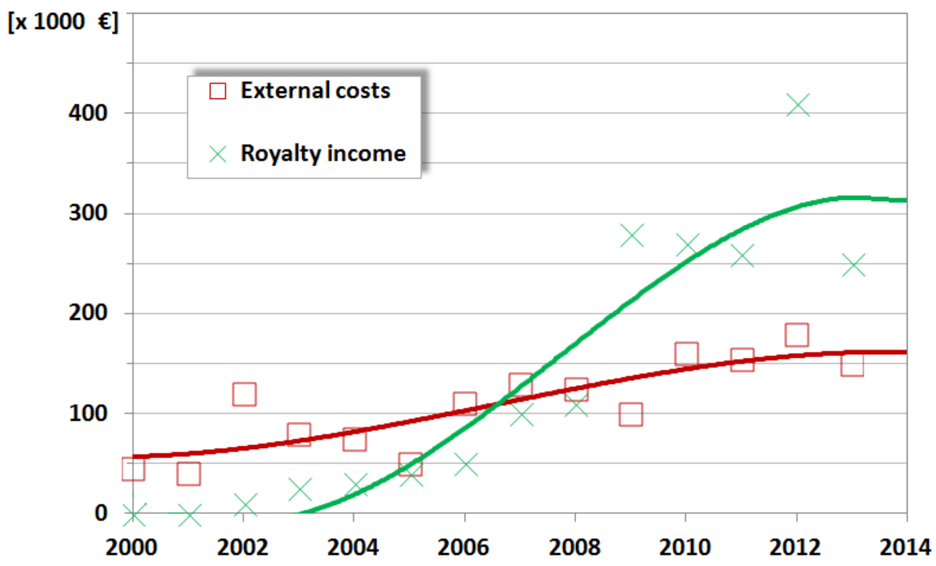

Fig. 6: Total external costs (red), consisting of fees for patents and patent attorneys. Over a decade costs increased marginally, whereas the number of patents of Figure 5 *multiplied greatly. The royalty income curve of this figure (green) trails the patenting curve of Figure 5 by about 4 years. Note that the last five years generated about € 1.4 million in royalties or sales, distributed to the inventors as an incentive (30 %).*

The income curve of Figure 6 trails the patenting and licensing activity by about four years, taken at half of the current saturation value: taking research technology from the lab to the market takes time. The time lag seems reasonable for the engineering sector which we are contracting in. A recent paper simulates this time lag effect (Kim, 2013). For the medical or semiconductor industry this may well be much larger than for our portfolio.

With respect to royalties generating contracts we follow a key account management (KAM) process which realizes multiple contracting for long-term clients. At the same time all offers are transparently displayed on the internet (PTB, 2014) and will lead to non-exclusive licenses, if there is more than one interested party. The distribution of contract royalties is shown in Figure 7.

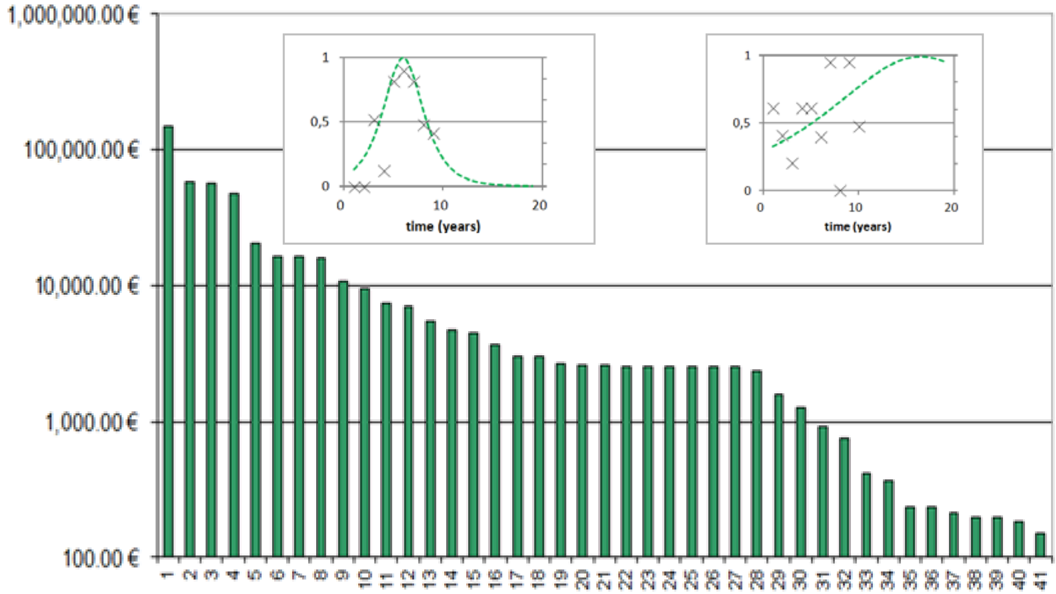

Fig. 7: Distribution of contract royalties for 2012. The logarithmic vertical scale shows that the distribution is highly skewed. Only a small fraction of the contracts earns most of the money. Nevertheless PTB follows a policy for all interested parties, because even the lower earning contracts may well create interesting novel products for an SME. The inset shows a typical example of the time development of earnings after contract signing. The data are normalized for anonymity. The left inset is one of the key accounts (1 through 8), the right-hand inset is one of the lower earning contracts (9 through 41). The green lines represent fits according to the Bass diffusion model of market uptake, explained in the text (Maiorov, 2012). It takes about 5 years to generate substantial earnings. Peak sales are expected for 5 years on the left and about 15 years on the right, the latter at a lower income level.

Figure 7, with its logarithmic vertical income scale, is indicative of the highly skewed distribution of royalties. This is very well known from the literature (Scherer, 2000; Verspagen, 2006). PTB follows a broad licensing scheme, enabling SME to have access to all of our technologies. A purely profit-oriented approach would have canceled the underlying patents of the 15 to 41 contract range at an early stage.

The inset shows one example of a key account (from contract 1 through 8) and one example of a lower earning contract (9 to 41). The data are normalized to 1 to maintain anonymity. The green dashed lines are fits by the Bass diffusion model for the market introduction of innovative products (Maiorov, 2012). The model consists of a simple first order differential equation with two generators: marketing directly to the first customers and sales through market awareness, once the first units of the novel product are sold. Given the stochastic nature of a yearly sales rate, the model follows the data quite well.

It can be seen that the time lag for market uptake after the signing of the contract with PTB is about four years and the best sales are expected for another four years. These seem to be typical values in the market branches PTB is working in, depicted in Figure 3. For the right-hand inset the uptake is similar, but the half-width is about 15 years and typical for niche markets.

7 Comparison to European studies

When comparing licensing income, there is a huge difference between licensing royalties paid within industry and licences resulting from public R&D. A pan-European survey of more than 9000 companies resulted in a net reporting of approximately € 120 billion (Gambardella, 2008), summation by the authors. In contrast, the pan-European survey of university and research institute licensing reported a total of € 143 million (Arundel, 2012). Transparency in the field is not high. Gambardella et al. suspect a slight over reporting by the companies, but the difference in order of magnitude with respect to public R&D licensing is still noticeable. A compilation by the authors, using internet data from the most well known key players in German R&D, results in an upper value for German R&D licensing of € 250 million at the most. On the other hand, licensing income from export, apparently a small fraction of total licence income, is already € 5.5 billion in Germany (Bundesbank, 2011). Note also that the estimated upper limit for German public R&D licensing is considerably above the total of Europe, as reported by Arundel et al. (Arundel, 2012). In summary, R&D licensing from public R&D is several orders of magnitude away from licensing royalties for developed technologies of private companies.

In both cases, a highly skewed distribution is reported, similar to the one depicted for PTB in Figure 7. A clever scale invariant representation of these distributions can be achieved by constructing a Lorenz curve (Gastwirth, 1972), not to be confused with the mathematical Lorentzian distribution function. The curve starts from a given probability distribution which is divided or binned into income ranges. By subsequently adding each binning range to the next bin of the income range eventually 100 % of all income and 100 % of all elements the sample group are accounted for. The result is shown in Figure 8. This scheme is independent of the income category ranges and of their absolute value. Different distributions, such as the one for R&D and for the private sector turn out to be comparable.

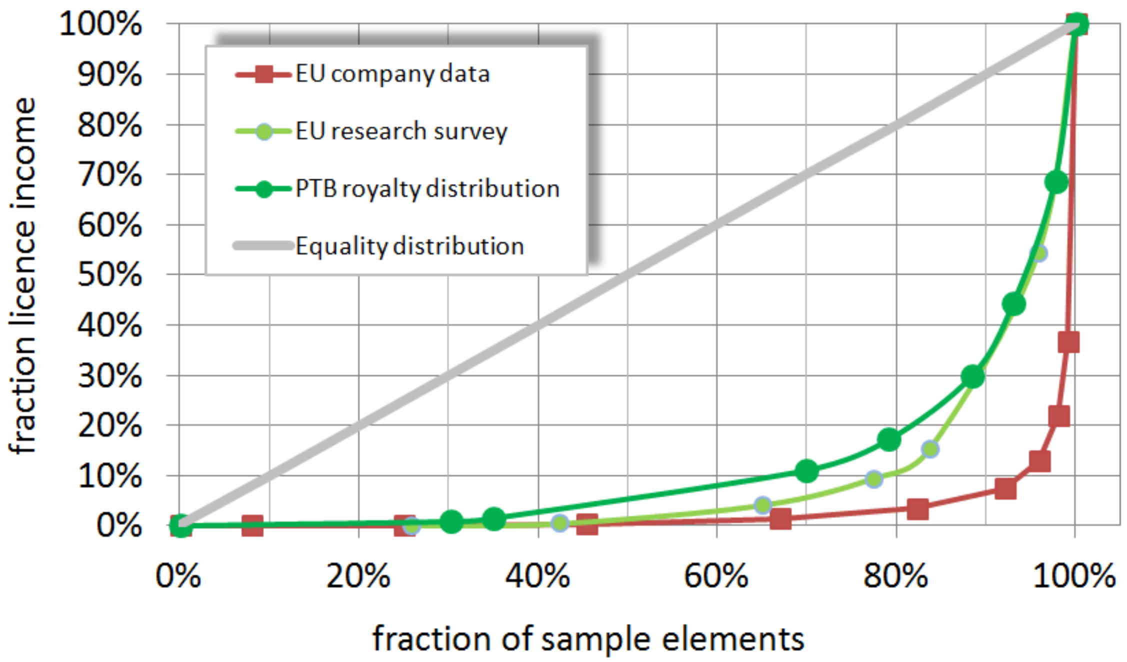

Fig. 8: Lorenz curve of licence income distribution for EU private companies, income of universities and research institutes and PTB. The curves are obtained by adding the fraction of total income for the respective fraction of the sample group. The grey line represents total equality, meaning each patent earns exactly the same royalties. For the red company curve the diagram reads like this: 95 % of the patents earn 10 % of the income, while the remaining 5 % earn 90 % of the income (Arundel, 2012; Gambardelle, 2008).

As explained in the caption to the above diagram, for the private sector case 5 % of the patents earn 90 % of the income. For licences resulting from public R&D the curve is slightly less skewed, still 20 % earn 80 % of the income – the classical Pareto ratio. For PTB, the distribution is a little more equal, resulting from its policy approach to serve even low income licensees as part of its public task explained earlier.

Now following the reporting line of Arundel et al. (Arundel, 2012) for the public sector, Table 2 contains the main findings and compares them with PTB. For the income from licences it must be noted that, as a result of the survey for the public sector, a surprising 89 % of licence income originates from the life science and bio-tech sectors. As we do not work in this field, we rescaled the income parameter by 0.11.

Key indicator figures (KIF) per 1000 research staff (FTE)				
	Universities	Research institutes	PTB	Reasonable average range estimate
Invention disclosures per year	16.9	13.7	13.2	10 to 21
Patent applications per year	8.4	10.9	8.0	6 to 13
Licence agreements per year	9.0	5.8	4.2	5 to 11
Start ups	2.2	0.8	0.1	0.6 to 2.7
Licence income per year [million €]	0.06	0.15	0.20	0.06 to 1.4
Licence income per year (ProTon) [million €]*	0.26 – not normalized to FTE		0.25	-
Licence income per year (ASTP) [million €]*	0.93 – not normalized to FTE		0.25	-

*Tab 2: Comparison of PTB KIF with pan-European survey (Arundel, 2012). Data are average KIF per 1000 FTE. Included are two other European surveys (*Piccaluga, 2011). However, they do not give data sets normalized to 1000 FTE. PTB holds an average position, if normalized to the FTE of Table 1. If technology transfer KIF were normalized to our 60 % R&D ratio, the PTB data would be substantially above average. The "reasonable average range estimate" is explained in the text.*

PTB data of Table 2 are underestimations, because we normalized the data to the 100 % FTE of Table 1, whereas the R&D component of our work – as explained earlier - only amounts to about 60 % of our budget. Start-up rate is not surprisingly small because of the niche markets for direct technology transfer in the realm of metrology.

The data for PTB in the first three lines are surprisingly close to the average. We consider this closeness to be an artifact. To obtain an orientation of these KIFs with respect to the underlying data distribution, we created the "reasonable average range estimate" column. For the first four lines it is calculated by taking 25 % off the minimum and adding 25 % to the maximum of the first two columns. For the licence income range it is a direct quote for the university average and the research institute average from Arundel et al., 2012.

In summary, after 10 years of operation we are performing - with a TTO-staff of three FTE - well within the European average.

8 Conclusions and recommendations

PTB views knowledge and technology transfer as part of an innovation system, with the main routes being standardization and cooperative applied research with industry and SME. IP protection and licensing is a minor, but vital part of these processes. IP management is necessary for the integrity of the institution, safeguarding a transparent and clearly defined transfer process for all market participants and the public. More than ten years of activity have resulted in an average position within the European transfer scene, as it is known today.

Based on our experience, a successful technology transfer should encompass the following aspects

- Define a benchmark invention rate, which gives you a sufficient number of possible valuable patents, but does not swamp the TTO with low quality inventions
- Pursue a licensing strategy that is embedded in the activity of the departments, especially for the procurement of public funds for functional prototype development
- Take the inventor as the key lead to the company customer
- Assume at least a four-year delay before the onset of noticeable royalties
- Work for, but do not expect, net profit from royalties
- Based on the half-life of a new product in the engineering sector, aim to win at least two high earning key accounts every five years.

Although IP licensing is a market activity, if individual contracting is addressed, nevertheless the interdependency with the overriding public goals of market neutrality, aiding SME in functional prototype development and broad dissemination through standards should be at the heart of the technology transfer subsystem of IP management.

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