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The Innovation Potential of Universities - An Explorative Analysis

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The Innovation Potential of Universities - An Explorative Analysis [1]

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Abstract

Knowledge-based innovations are a main driver for economic development of countries and a key factor in global competition. Most industrial countries aim to strengthen their innovative capacity breadthways. Beside large firms especially universities have the necessary potential (infrastructure and knowledge) to be regional drivers of innovations. They develop innovative ideas on their own and even more important support R&D-activities of the local economy. This paper offers a methodological framework for exploring the potential for commercialization within universities. The importance of inventions, publications and third-party funds as objective indicators is highlighted, and an additive value function is introduced to measure the potential for commercialization. Based on expert interviews at a technical university the required weights for all considered indicators are exemplarily identified. By applying different models to aggregate expert weights robust rankings of university units with respect to per-capita and overall potential for commercialization were found. Based on these measures a central transfer unit could be able to allocate transfer-oriented resources properly. The specified scoring approach is a first step towards an EU-requested evaluation system.

Keywords: knowledge transfer, potential for commercialization, patent, invention, university
JEL Classification: I23, O31, D81

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1. Motivation and Research Question

Economists confirmed long ago that R&D is the central determinant of GDP-growth and hence of employment as well.[2] Among politicians this is already a strong conviction. Innovations constitute the core element of the „EUROPA 2020"-Strategy to improve growth and employment stimuli (European Commission, 2011). The central role of R&D activities as drivers of innovations has been established by the transnational EU-target to invest three percent of GDP in R&D each year. To date, most R&D activities are carried out by a small number of large firms (Konzack et al., 2011) and therefore attract substantial subsidies. The European economic policy for the structural funds period 2014 to 2020 aims to strengthen the innovative power of the economy, in particular by utilizing the potential of medium sized firms.[3] Consequently, the foundation of individual innovation strategies should account for structural differences of regions.

Universities can take a key role as regional drivers of innovations (Rampersad et al., 2012; Fransman 2008). They have the potential, in particular the required infrastructure and knowledge, to not only create distinct innovations but even more important to support R&D activities of the local economy (Philpott et al., 2011). Currently universities are disavowed to have a sufficient consideration of the regional research demand (Becker et al., 2013). According to the EUs vision they should, therefore, develop knowledge based products and services close to markets and professionalize their transfer structures. Under the supervision of the federal state government individually adapted evaluation systems should be installed to guarantee transparency and sustainability of the required measures (European Commission, 2011). Additionally, universities have an increasing self-interest to improve the exploitation of their transfer potential in order to compensate the conceivable reduction of federal funds. The commercialization of academic knowledge is supposed to increase the financial independence of universities (Siegel et al., 2004).

This paper aims to identify the transfer relevant potential of research institutions. Section 2.1 presents a characteristic transfer process of a German university, since transparency is a basic requirement for the necessary evaluation system. In general, there is no significant data available that directly measures the return flow from commercialization of knowledge per structural unit. Therefore, an estimation of transfer potential has to be based on different indicators.

[2] We refer to the seminal growth literature: Solow (1956), Swan (1956), Romer (1990), Grossman/Helpman (1990), and Aghion/Howitt (1992).

[3] In Germany the overwhelming majority of firms are small. 90 percent of companies have on average less than ten fulltime equivalent employees and therefore do not possess the critical size to carry out successful R&D on their own. At the same time the ability to use external R&D is limited (Becker et al., 2013). There is no evidence so far, that networking among medium sized companies (the cluster initiative) had a significant impact.

As a result of a literature review, section 2.2 identifies **publications**, **patents** and **third party funds** as the most suitable indicators. With the assistance of a scoring model the structural units with the highest commercial potential are revealed. In section 2.3 an additive value function is introduced and the underlying assumptions, in particular the independence between the four indicators, are discussed. To demonstrate the applicability of our approach section 3 underlines the findings by using empirical data from the Otto von Guericke University Magdeburg. Following the descriptive statistics of all indicators, different weighting models on the basis of 18 expert judgments are introduced. Subsequently, we use the weights and performances for all indicators and determine the per-capita and overall potential of commercialization for all structural units. Since the results constitute sensitive data, experts as well as structural units are anonymized. A comparison of the seven proposed weighting models reveals that, despite clear differences in expert judgments, rankings of structural units might be quite robust. As a result a reliable potential-oriented allocation of resources is possible.

The last section gives policy recommendations and discusses implications for further research. Our explorative investigation is a first step in explaining the differences in commercialization potential of research results. Additionally, this scoring approach is intended to be an integrative part of the required evaluation system, and it is, therefore, able to contribute to the „EUROPA 2020“-targets.

2. Methodology

Universities with well-established transfer structures and a clear focus on the commercialization of knowledge would base their optimal comparison of structural units, e.g., institutes or chairs, on the revenues per year generated by transfer efforts. Since most universities do not have the necessary commercialization culture and history, alternative methods for measuring transfer potentials have to be sought. Existing analyses are primarily output-comparisons of research institutions.[4] To determine the commercialization potential of structural units and to derive policy implications we need to take three pivotal steps: First, the identification of the current transfer process for the considered university; second, the discussion of possible indicators to measure transfer-relevant activities and third, the aggregation of chosen indicators to a single index using a legitimated value function.

[4] Pohlmann (2010) investigates the transfer potential of equal departments of Hessian universities with the efficiency based Data Envelopment Analysis method. For details to that method see e.g. Cooper et al. (2007).

2.1 The Economic Transfer Process

Based on interviews carried out with experts from all transfer related institutions as well as most important decision makers of a German middle-sized university, we identified all relevant players and activities as well as a time sequence. Figure 1 provides an overview of this current economic transfer process. It corresponds to the pure commercialization process of intellectual property rights, because other forms of knowledge commercialization activities are often not implemented. As a first step scientific initial ideas submitted by all academic levels are examined by the patent information centre (PIC) with respect to general patentability. On the basis of this university-internal recommendation the inventor itself decides whether or not to register officially at the university.

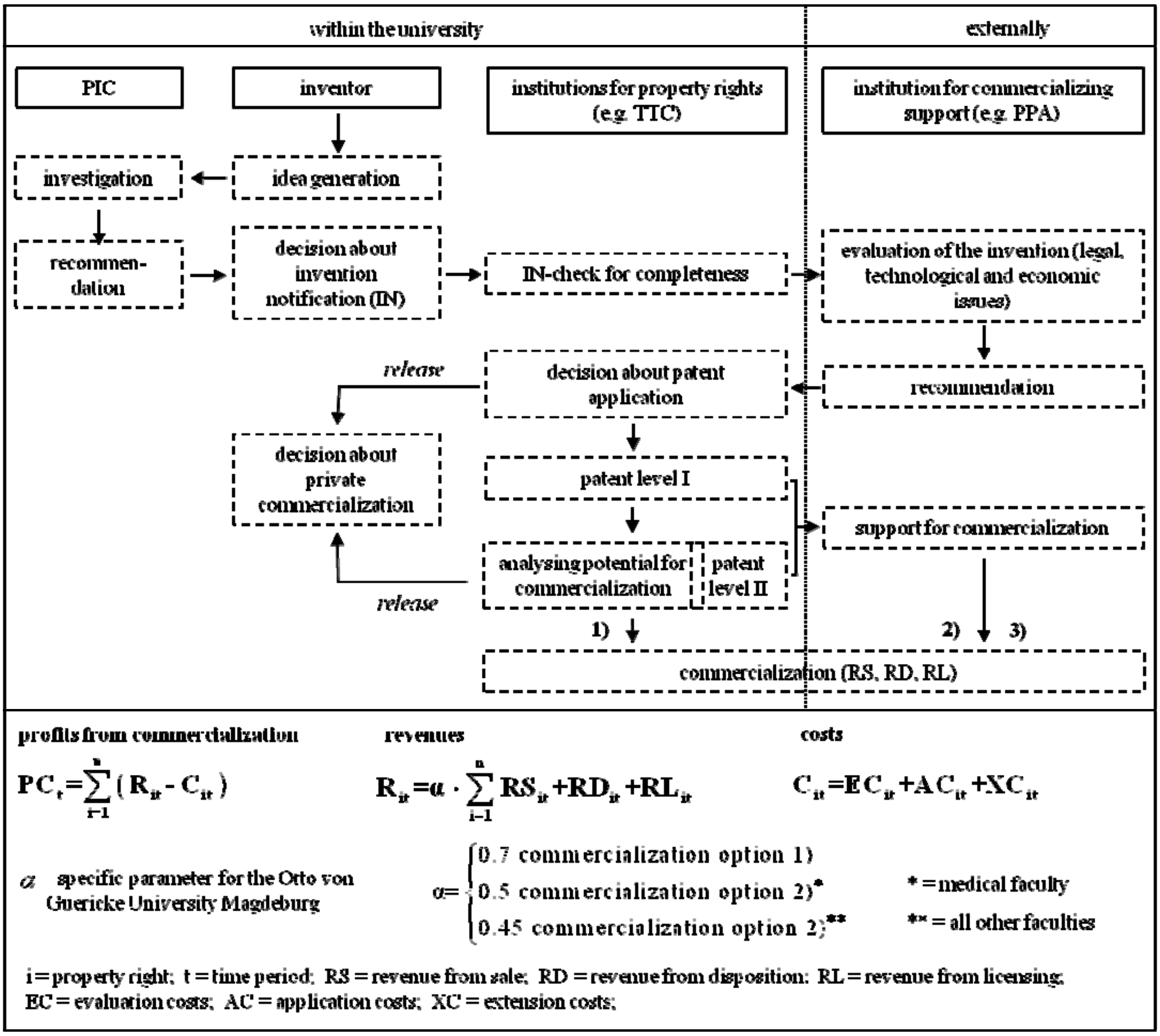
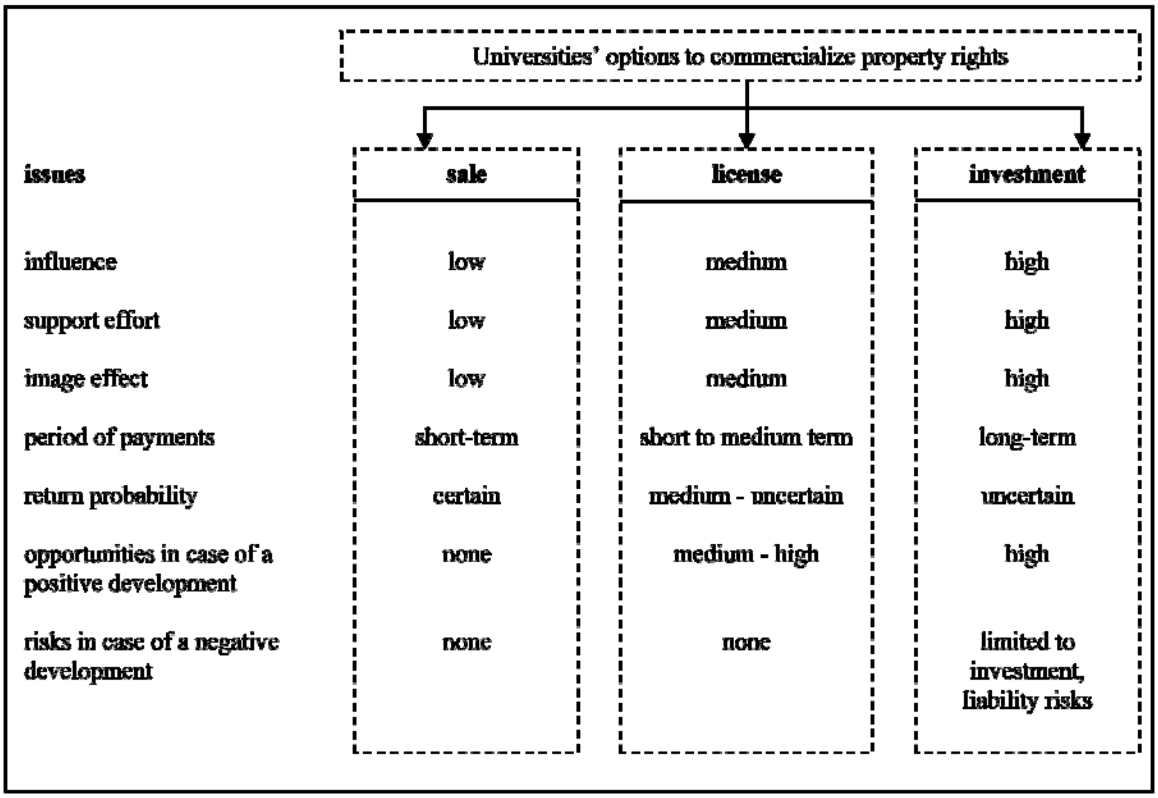


Figure 1: Economic knowledge commercialization process of a German university

Registrations of inventions have to be addressed to a central unit, often organized as a technology transfer centre (TTC), where a check of completeness is conducted. Subsequently, the registered invention is handed over to an external patent processing agency (PPA), where the university holds a minority investment. This institution examines the patentability as well as technological and economic aspects, i.e., a first check of the marketability of an idea takes place. On the basis of their overall judgment the university decides whether or not to apply for a patent.[5] In case of a negative vote the university usually returns the invention to the scientist. With the right to privately commercialize the invention the scientist is entitled to withdraw all resulting profits. In case of a positive decision a multi-stage patenting process is initiated, although releases of the invention to the scientist due to new information can occur at any time. Throughout this long-lasting procedure the patent processing agency continuously investigates the potential of commercialization.

Generally speaking a university can commercialize patents in three different ways: **sale**, **licensing** and **investment**. Figure 2 shows their specific characteristics.



Universities' options to commercialize property rights			
issues	**sale**	**license**	**investment**
influence	low	medium	high
support effort	low	medium	high
image effect	low	medium	high
period of payments	short-term	short to medium term	long-term
return probability	certain	medium - uncertain	uncertain
opportunities in case of a positive development	none	medium - high	high
risks in case of a negative development	none	none	limited to investment, liability risks

Figure 2: Refinancing options for universities[6]

The generated revenues represent discretionary financial means, which, reduced by legal obligations, can be used for any purpose. Currently the investment option cannot be realized at most universities due to an insufficient commercialization infrastructure. In particular a mature legal framework and an affiliated investment company to grant seed money for entrepre-

5 A study by Cuntz et al. (2012) shows, that in Germany only one out of three inventions registered by patent processing agencies is actually patented. In contrast at some research institutions a patentability process is initiated for every single invention which can be traced back to a possible pre-selection process of the PIC.

6 Own depiction according to BMBF (2004).

neurial spin-offs is missing. Universities in general still balk at the entrepreneurial risk and the effort needed for supervision as well as support. Nevertheless „Europa 2020“-targets highlight the increasing importance of this transfer option (Bagdassarov, 2012), forcing politics to encourage universities to establish suitable structures for its realization (Becker et al., 2013). Depending on the chosen commercialization channel universities generate different revenues and costs, as specified at the bottom of figure 1. In practice, universities often prefer licensing as a commercialization option (BMBF, 2004).[7] A major challenge for universities is the individual comparison of all commercialization options, since different opportunities and threats need to be contrasted and quantified. If available, the competencies of an entrepreneurship center with regard to the guidance of a full business planning process should be used.

2.2 Indicators of the Commercialization Potential

Indicators in the context of innovations are mainly used to offer insights to the input-output process. On this basis a performance comparison of innovations can be conducted and measures can be derived (Mairesse/Mohnen, 2010). Although the literature features a multitude of operating figures, basically differentiating between qualitative and quantitative indicators (Werner, 2002), so far no scientific approach to measure the potential of innovations has gained full acceptance among researchers (Hagedoorn/Cloodt, 2003). Qualitative assessments of commercialization potential usually originate from expert interviews. Personal preferences of participants may distort these results, and hence their comparability is limited. Moreover, the collection of a multitude of expert opinions comes at a great expense. Business innovation and market innovation for example are indicators for corporate assessment with a qualitative character (Acs et al., 2002; Kleinknecht et al., 2002 and Hauschildt/Salomo, 2007). There internal decision makers are responsible for evaluating, whether an invention is classified as a market innovation or only as new to the company.

In practice quantitative indicators for evaluations of innovations have a broader acceptance, because of their higher level of objectiveness. Exemplarily, the amount of patents (Acs/Audretsch, 1988), the expenses for innovations (Lööf/Heshmati, 2006), and the number of R&D-personnel (Brouwer/Kleinknecht, 1999) are applied, since they can be determined with low effort and without ambiguity. Single operating figures having advantages and disadvantages can only explain a certain part of the commercialization potential. Therefore, a combination of the most accepted indicators (a multiple indicator approach) can deliver a more

[7] At the Otto von Guericke University, for example, from 2007 to 2011over 70 percent of all revenues from commercialization of academic property rights stem from licensing. Revenues from property right sales are almost exclusively generated at the medical faculty. Strongly fragmented property rights make the use of other commercialization options nearly impossible.

complete evaluation of the innovation potential (Hagedoorn/Cloodt, 2003). However, innovation indicators used for business internal assessments cannot be perfectly transferred to the public research sector. It is necessary to use specific operating figures to consider the three main missions of universities: research, education and transfer. In addition to the direct amount of inventions, third-party funds and publications give evidence to the performance of structural units in the public sector.

Inventions

An invention is the result of R&D and a new technical solution of a specific problem (Pleschak/Sabisch, 1996). Since the German privilege for scientific staff to commercialize their own findings was repealed in 2002 (ArbEG §42), a university now possesses all intellectual property rights that originate within the university. All employees have to register research outcomes that can be commercialized. Usually this obligation to report inventions already in an early stage should lead to a reliable indicator for the commercialization potential. In practice, however, there is a low awareness to this obligation, due to an insufficient communication. Moreover, the incentive structure is not optimal and a penalty mechanism is missing. Often there is no reliable data about the registered inventions available.[8] Therefore, the number of patents can only serve as an approximation. A patent is an exclusive commercialization right for a certain invention granted by a federal authority (Specht et al., 2002). Granted patents are suitable indicators for new knowledge that can be commercialized (Hülsbeck, 2011), because the patenting process follows a standardized and transparent procedure (Pohlmann, 2010). The number of patents is commonly substituted by the number of patent applications, since patent test procedures are time consuming (Cuntz et al., 2012; Edler/Schmoch, 2001). On the other hand, data concerning property rights released to inventors or transmitted to external research partners[9] often exist. The overall number of inventions of a research institution is thus approximated by the sum of patent applications, released inventions, and transmitted property rights.[10]

[8] In order to enable a comparison of different universities, this indicator has to be adapted to the individual transfer framework. If, for example, the PIC conducts an intensive patent examination before an invention is officially registered the overall number of registered inventions is considerably lower.

[9] The transmission of property rights is mainly based on cooperation agreements with companies, whereas most of these projects are direct research assignments.

[10] Two types of distortions are possible: First, inventions that cannot be patented and are commercialized by the university are not considered by the approximation. Second, an overlap of these three categories could happen, e.g., an invention is patented and later the right to commercialize it is returned to the inventor. This double count is expected to have a low distortive impact, because a scoring takes place before the different indicators are summarized in a value function. Therefore, the absolute number is always between 0 and 1.

Third-party funds

Third-party funds have a growing importance as indicator for the scientific productivity of research institutions (Zißler, 2011). There is a direct relation between the success to acquire third-party funds and the research performance (Schmoch/Schubert, 2009). Due to the simple determination and unambiguousness, this operating figure is widely accepted in science as a performance measure (Pohlmann, 2010). With respect to the source of funds we distinguish between private and public third-party funds. Research based on private third-party funds is a classic transfer standard in public research institutions and increases in importance because of the expected decline in budget funds for most universities. Private funds are mainly provided by the industry and therefore a measure for direct knowledge transfer assignments. In contrast, public funds are rather intended to increase research capacity and transfer potential. Therefore, industry funds are a direct measure for the transfer orientation of a research institution since a company commissions to solve a clearly defined problem (Gonska, 2007). This contract research[11] is the most direct form of transferring concrete and applicable scientific research results. An empirical analysis calls for the distinction between public and private third-party funds allowing consideration of these different aspects. Funds that cannot be assigned are treated separately under the category miscellaneous. For all categories we only consider the sum of funds, i.e., we do not discriminate between the sources of funds.

Publications

In general, the academic productivity is measured by publications in a quantitative and a qualitative dimension. Publications keep record of the latest research results and determine among others the market price for external research contracts via related reputation of scientists in the academic community (Zißler, 2011). Research results, in addition, indirectly indicate the commercialization potential of structural units. The reputation of a researcher is typically measured by bibliometric procedures with indicators such as the amount of publications or the number of citations (Hülsbeck, 2011). Modern rankings for researchers like the German ranking of the journal Handelsblatt for economists also consider the qualitative aspects and have a considerable informational value within certain disciplines. To measure and compare the scientific performance of different disciplines is difficult due to the different specifics (Pohlmann, 2010). These approaches only partially represent the transfer orientation of research institutions (Edler/Schmoch, 2001). For a complete evaluation of research achievements we need to consider books, dissertations, miscellanies, reviews and editorial scripts as

[11] Industry research partners often insist on exclusive property rights for private commercialization. Thus, they fully finance the necessary research activities within a fixed contractual framework (Gonska, 2007).

well (Münch, 2006). This necessity can be attributed to the diverse publication preferences of different disciplines. We acknowledge this aspect in our investigation and hence approximate the publication performance by the unweighted sum of all publications. We abstain from a qualitative weighting to avoid interdisciplinary distortions.[12]

The presented research design is exclusively based on operative figures that can easily be verified to achieve required objectivity. Despite their additional informational value qualitative factors are ignored. A systematic literature review identified **publications**, **patents** and **third-party funds** as suitable indicators to determine the commercialization potential at universities. Figure 3 shows the systematic composition of these indicators.

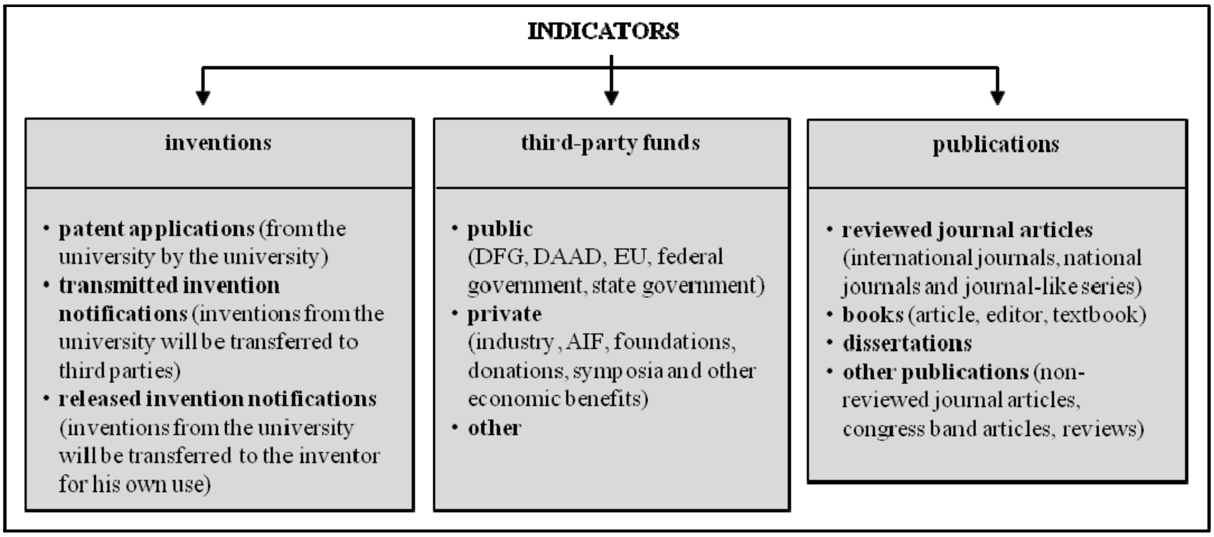


Figure 3: Indicators for the transfer potential

2.3 Aggregation of Proposed Indicators

In decision making the employment of different indicators describes the setting of a multi-criteria decision problem. To compare alternatives (here: structural units of a university) we have to aggregate different information with a value function. So far, in the literature a value function has not been used to determine the commercialization potential of research institutions. By introducing the approved SMART-method (Simple Multi-Attribute Rating Technique) we can form a single operating measure which combines different influence factors (Goodwin/Wright, 1998). In order to apply the SMART-method, our value function needs to

[12] E.g., often medical and economics faculties focus on peer-reviewed journal articles whereas in mechanical engineering many researchers publish monographs. Even if the same publication channel is used, disciplines considerably differ in the length of publications or the number of authors. For reason of simplicity these aspects are not taken into consideration although it could lead to distortions in per-ratio- and overall commercialization potential. In particular we observe a tendency of medical faculties to list significantly more authors on quite short paper compared to other disciplines and therefore carefully interpret the good publication performance of most medical units. More detailed information with respect to quantity and quality of publications can be found in Schläpfer (2013) and Combes/Linnemer (2010).

be additive and separable. This basically requires that all indicators can be evaluated independently. Otherwise it could lead to distortions from over or under weighting. In that case we need statistical procedures that control for autocorrelation of explanatory variables. If all assumptions are fulfilled, the standard value function can be applied.

We normalize the performance value per-capita to account for the different dimensions of all indicators. In this scoring approach the structural unit with the best performance for an indicator receives 100, the worst 0 points. All other performance values have to be scored accordingly within this range. The weights w_i of the value function are based on expert opinions. We ask experts for swing weights (Goodwin/Wright, 1998), because they express the relative importance of an indicator as well as the magnitude within indicators. If the difference between structural units is small, an indicator will receive a lower weight and hence will have a lower influence on the overall value. The received swing weights are normalized and therefore add up to one.

$$v\left(SU_j\right) = \sum_{i=1}^{4} w_i \cdot v_i\left(x_j^i\right) \qquad \text{where} \quad \sum_{i=1}^{4} w_i = 1$$

The overall value $v\left(SU_j\right)$ of structural unit j (j=1..n) is the sum of all per-capita performance values $v_i\left(x_j^i\right)$ for the four relevant indicators x_j^i weighted individually with w_i. Our four independent indicators provide different evidence for a high potential of commercialization of knowledge per structural unit. With the above provided additive and separable value function we can compare all structural units on the basis of a single effectiveness measure $v\left(SU_j\right)$. The per-capita commercialization potential of each structural unit is accordingly valued within a range of 0 to 100 points. The next section presents an empirical test of our approach and discusses different models to determine the weights for our four indicators.

3. Empirical Investigation

In order to test our methodology we carried out an empirical investigation at the Otto von Guericke University Magdeburg (subsequently OvGU). This university is about to establish a commercialization infrastructure and has no sufficient commercialization history. Therefore no significant data is available so that a direct measurement of the commercialization potential is not possible. Currently the OvGU exclusively commercializes intellectual property rights. Knowledge transfer through education, consultancy and professional presentations however is not yet centrally organized and therefore not part of our investigation. In order to test our methodology we collected data with respect to the four proposed indicators from 2007 up to 2011 for all structural units predominantly from the university information system (HIS) and the annual publication report provided by the TTC. HIS contains data about third-party funds and the number of employees per structural unit. Not until the number of employees is considered is it possible to receive a significant comparison of all structural units. The annual publication report of Saxony-Anhalt additionally lists all scientific publications, invention notifications, released inventions and patent applications. The necessary data set is completed by the number of patent inquiries of the PIC. All data has been aggregated in our four indicators as described in chapter 2.2. An explorative data analysis of all indicators provides an overview of various performance measures at the OvGU. The box plot in figure 4 summarizes this information and highlights outlying as well as extreme values for all variables.

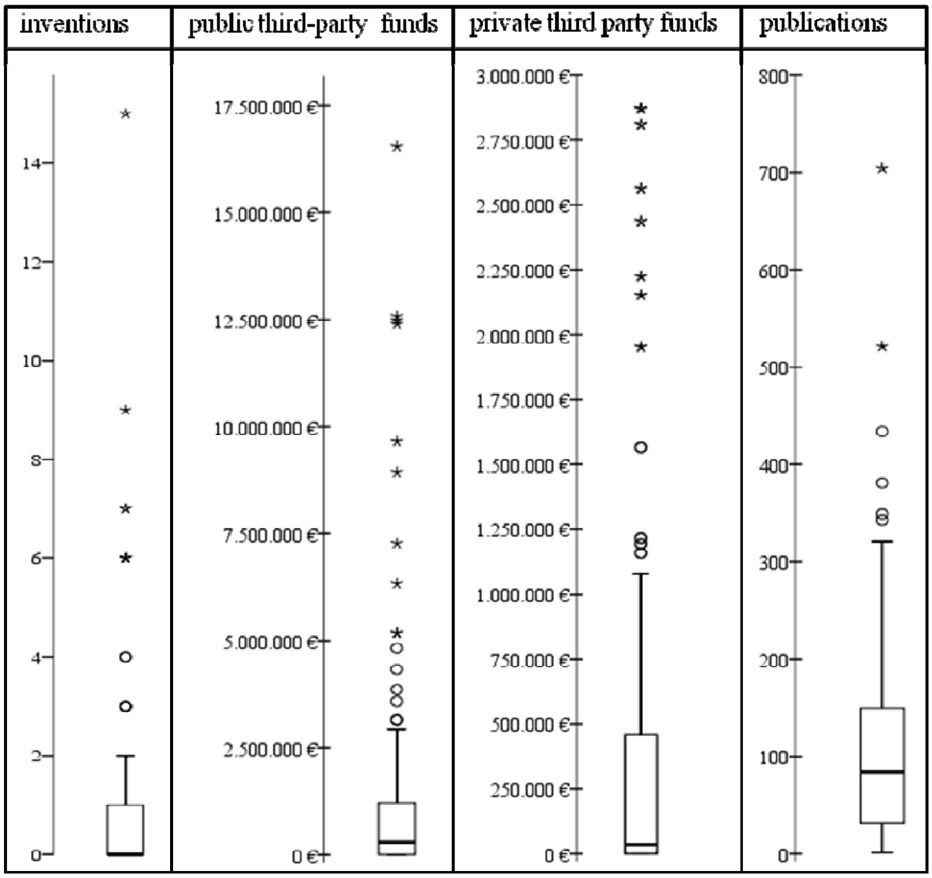


Figure 4: Boxplots of the four indicators

A value is outlying (extreme) if it is more than twice (four times) the length above or below the box. Outliers are indicated with a circle, extreme values with an asterisk. If a survey includes the all alternatives, outliers and extreme values are part of the entity. It is not allowed to eliminate them, because they shape the actual picture (Johnson et al., 2002).

In order to apply the value function introduced in section 2.3 we need to control for possible dependencies between indicators. Naturally a large structural unit is expected to create more inventions, collect more third-party funds and have a greater number of papers published. The resulting high correlation between indicators can be eliminated by comparing the indicators on a per-capita basis. Thus, all indicators are set in relation to the amount of full-time equivalent positions in our value function. A correlation analysis of all per-capita indicators can proof their independency. At the OvGU we determined the annual per-capita indicators as average over the period 2007 to 2011. Table 1 summarizes the results of the correlation analysis. The correlation matrix confirms only a moderate positive correlation between private and public third-party funds per-capita on a one percent level of significance. Nevertheless, the scatter plot of figure 5 reveals no systematic dependency between both indicators.

Correlation Matrix of the Average Standardized Indicators (2007-2011, cases n=565)					
		publication/ST	inventions/ST	public third-party funds/ST	private third-party funds/ST
publications/ST	correlation (Pearson) significance (double sided)	1			
inventions/ST	correlation (Pearson) significance (double sided)	.020 .641	1		
public third-party funds/ST	correlation (Pearson) significance (double sided)	.013 .758	.045 .288	1	
private third-party funds/ST	correlation (Pearson) significance (double sided)	.012 .773	.079 .060	.137** .001	1
**. The correlation is significant on the 0.01 level (double sided). ST-Staff					

Table 1: Correlation coefficients between all per-capita indicators

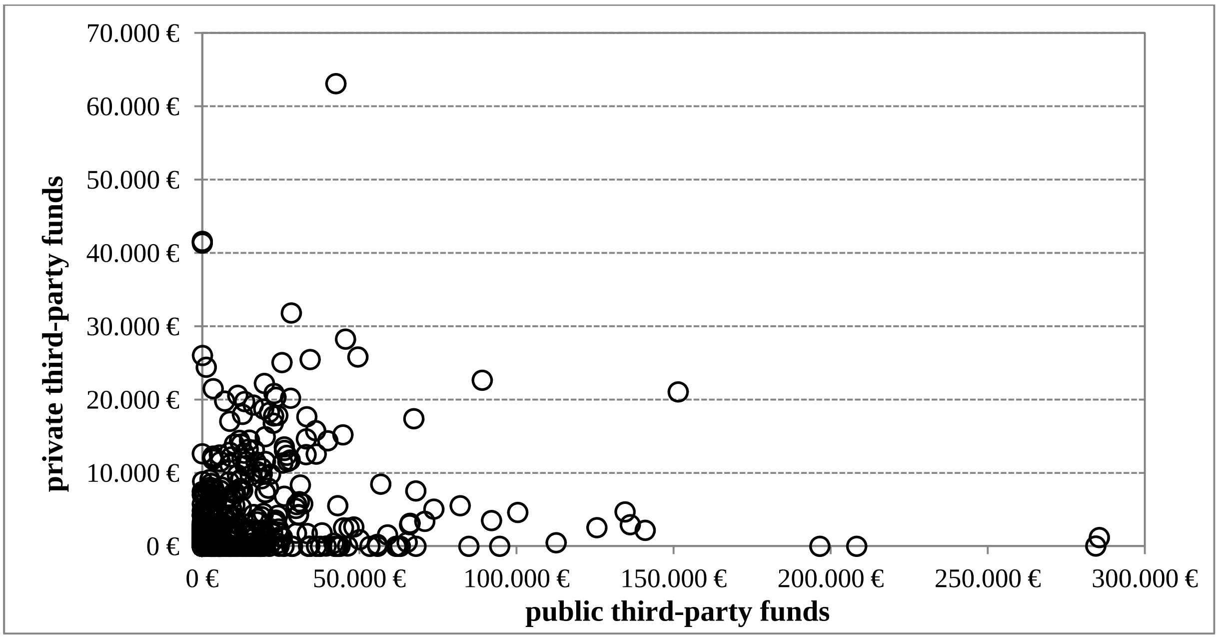


Figure 5: Scatter plot of the average private and public third-party funds per employee

In order to derive clear implications, all structural units should be represented by a single measure. The value function proposed in chapter 2.3 requires a weighting of the scored performances for the introduced indicators. So far, in the literature there is no accepted empirical attempt to establish weights for indicators. In our study we ascertain these weights on the basis of expert interviews with 18 transfer relevant decision makers of the OvGU. Nine central transfer agents complement a transfer-affine representative of each faculty. We identified significant differences in weights between the involved experts. Table 2 summarizes the anonymized results.

area/indicator	inventions	public third-party funds	private third-party funds	publications
transfer area				
transfer agent 1	0,200	0,350	0,350	0,100
transfer agent 2	0,300	0,200	0,200	0,300
transfer agent 3	0,600	0,150	0,200	0,050
transfer agent 4	0,400	0,200	0,300	0,100
transfer agent 5	0,050	0,375	0,375	0,200
transfer agent 6	0,200	0,200	0,200	0,400
transfer agent 7	0,200	0,300	0,300	0,200
transfer agent 8	0,400	0,200	0,100	0,300
transfer agent 9	0,000	0,100	0,900	0,000
faculty				
faculty 1	0,100	0,200	0,300	0,400
faculty 2	0,100	0,400	0,300	0,200
faculty 3	0,100	0,800	0,100	0,000
faculty 4	0,100	0,300	0,300	0,300
faculty 5	0,100	0,300	0,200	0,400
faculty 6	0,300	0,200	0,300	0,200
faculty 7	0,000	0,200	0,050	0,750
faculty 8	0,050	0,400	0,050	0,500
faculty 9	0,050	0,350	0,250	0,350

Table 2: Weighting of indicators by transfer experts and representatives of all faculties

There is no ultimate way to handle diversity in expert opinions. Especially with respect to the competences of these two groups, transfer and faculty experts, various opinions exist. In general, with differing expert opinions diverse weighting philosophies can lead to significant variations in the ranking of structural units. The expected consequences are even more severe the smaller the transfer budget. If results critically depend on the chosen weighting model we expect a difficult discussion among decision makers. Our methodology will be a helpful guide in that process since the enhanced transparency enables better matching of university targets and consequences of resulting measures. Anyway, our set of proposed weighting models is not closed and institution specific adaptations are recommended. An ex-ante comparison of different weighting models could even serve as a mediator stimulating a better alignment of transfer relevant structures. We present seven different concepts aggregating 18 collected expert opinions. The resulting weights for all models are summarized in table 3.

- The first model represents the average of the weights of all 18 experts against the background of an equal consideration of transfer agents and representatives of the faculties.
- For model 2 we assume that only transfer experts possess the relevant know-how and hence calculate the weights as arithmetic mean of the nine transfer agents.
- In contrast, model 3 exclusively indicates the view of the nine faculty representatives by calculating the weights as their arithmetic mean.
- Model 4 accounts for the differences between the faculties with respect to the importance of indicators. Here the performance of all structural units is directly weighted with the particular faculty representatives rating while transfer experts are ignored.
- Model 5 is also only based on the faculty representative's weights, but concentrating on the average of the university's focus areas MINT, Medicine and Social Sciences.[13]
- Model 6 is a combination of model 2 and 4 pari passu. Hence, we consider the experience of the transfer experts and the individual preferences of faculties at the same time.
- Finally, model 7 accounts for situations in which a single person within a university has the sole responsibility for knowledge transfer. This central decision maker nominates weights for the indicators based on a profound transfer expertise and allocates resources and takes other transfer measures on the basis of the resulting rankings.

model/ indicator	inventions	public third-party funds	private third-party funds	publications
model 1 (university average)	0.181	0.290	0.265	0.264
model 2 (transfer experts average)	0.261	0.231	0.325	0.183
model 3 (faculties average)	0.100	0.350	0.206	0.344
model 4 (single faculties)	data single faculties			
model 5 (MINT/Medicine/ Social)	0.133/0.050/ 0.025	0.367/0.350/ 0.300	0.250/0.250/ 0.050	0.250/0.350/ 0.625
model 6 (combination model 2 and 4)	equal weighting of model 2 and 4			
model 7 (central planner)	0.200	0.300	0.300	0.200

Table 3: Models with different weightings of indicators

[13] MINT represents the following faculties: Mechanical Engineering, Electrical and Information Engineering, Science, Process and Systems Engineering, Mathematics and Computer Science. Social Sciences consist of Humanities and Economics.

Applying all different weighting models to the identified 113 structural units of the OvGU (a complete list can be found in the appendix) delivers seven different rankings of commercialization effectiveness and hence represents various philosophies. Table 4 shows the ten best structural units of the OvGU anonymized and arranged according to model 1 (the arithmetic mean of all opinions) in descending order.

unit/model	**M 1**	**M 2**	**M 3**	**M 4**	**M 5**	**M 6**	**M 7**
unit 1	44.93	49.54	40.35	46.24	43.98	47.77	47.54
unit 2	39.27	41.92	36.56	36.63	36.63	41.62	38.39
unit 3	38.19	42.42	33.91	30.19	36.79	41.28	39.88
unit 4	38.14	42.04	34.33	41.67	37.35	33.88	40.65
unit 5	36.93	40.76	33.13	35.99	34.66	36.66	38.21
unit 6	36.43	29.02	43.92	40.15	43.73	28.95	36.17
unit 7	30.89	32.19	29.61	34.23	30.12	30.82	31.44
unit 8	29.47	23.65	35.35	55.28	34.19	18.52	28.62
unit 9	29.38	30.16	28.61	31.57	28.09	28.40	29.23
unit 10	29,08	27.59	30.55	26.95	28.04	26.37	27.45

Table 4: Potential for commercialization per unit and employee -
TOP 10 in descending order according to model 1

The rankings provide valuable information. As the commercialization of knowledge is gaining in importance, a university can use the rankings to decide which scientific areas to promote in the future. A comparison of the seven rankings reveals isolated strong deviations in the performance of some structural units, but we observe relatively robust ranking orders. For the OvGU only structural units with extreme differences in the performance of the four indicators are prone to significant variations in the overall per-capita commercialization potential depending on the weighting model. Robust rankings have a main advantage: they facilitate a fast decision and foster the acceptance of resulting measures. For this reason it is meaningful to apply the seven weighting models prior to a discussion about the appropriateness of the involved philosophies. A central decision maker could even use this insight to delegate the selection of a weighting model. Although this will have little influence on the resulting strategic measures it signals democratic participation of lower management levels.

The per-capita commercialization potential is interesting in the long-run, since it has strategic implications for universities. But, which institute or faculty should be targeted first by the transfer unit? In the short-run it is more important to identify the existing overall potential of commercialization for each structural unit. We multiply the per-capita value of all alternatives with the number of full-time equivalent employees. The structural units with the highest overall commercialization potential within the OvGU are ranked in table 5 in descending order according to model 1.

A comparison of all seven weighting models on the basis of overall commercialization potential reveals that the resulting rankings are quite robust as well. Although the overall performance of some structural units strongly depends on the weighting philosophy (e.g., structural unit 5 ranges between position 4 and 13), the rank order is stable all together.

unit/model	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**
unit 1	1	3	1	1	1	1	1
unit 2	2	1	3	2	3	2	2
unit 3	3	2	4	9	4	3	3
unit 4	4	5	2	3	2	5	4
unit 5	5	4	11	13	11	4	5
unit 6	6	7	6	4	6	6	6
unit 7	7	6	9	6	8	9	7
unit 8	8	8	10	7	9	10	8
unit 9	9	12	5	5	5	12	10
unit 10	10	10	8	8	10	11	11

Table 5: Ranking of total potential for commercialization per unit –
TOP 10 in descending order according to model 1

The comparison of the two presented rankings contains valuable information about the type, the source and the composition of the commercialization potential of a research institution. We identified a large discrepancy between table 4 and 5. Among the 30 best structural units in the per-capita commercialization potential 1/3 of all institutes differs to the top 30 of overall commercialization potential, since a significant share of the structural units with a high commercialization effectiveness are quite small in size. Over all we found interesting patterns. As expected, the structural units belonging to the MINT-area perform clearly above average in both rankings independently of considered weighting model. Almost 2/3 of all units in top 30 rankings are assigned to the MINT-area. Structural units belonging to the medical faculty account for 25 percent. Hardly any unit from social science was able to enter any of the top rankings. Within the MINT-area the mechanical engineering faculty performed outstanding. All structural units from this faculty are among the top 30 rankings. More detailed results have to be treated as confidential.

4. Policy Recommendations and Research Implications

The proposed weighting models on the basis of expert assessments showed quite robust results at the OvGU Magdeburg. The overall commercialization potential highlights structural units (faculties, institutes or chairs) that should be targeted in the short-run, because central transfer measures there have a high leverage effect. In contrast, on the basis of the per-capita commercialization potentials, a university can shift priorities between departments in the long run. The transfer potential will therefore also influence the allocation of resources within research institutions. We identified the necessity to establish a detailed documentation of monetary returns from knowledge transfer in the future and to directly attribute these revenues to the identified structural units.

In a further step, it should be possible to estimate the real explanatory power of indicators with the help of an econometric model. The return from knowledge transfer of a university within a certain period of time is the endogenous variable and can be explained by our four exogenous variables (**publications**, **patents, private** as well as **public third-party funds**). The main advantage is a possible elimination of the subjective expert surveys, since the new data set enables a direct quantification of real weights for all indicators. The analysis of the residual within the econometric model is a domain for further research. This value could indicate the influence of informal transfer activities, which as of yet are under-researched. According to Proto et al. (2012) this transfer using social contacts is the main channel for new knowledge into the economy. If this evaluation holds we can expect a relatively low coefficient of determination.

In the longer run, it should be even possible to directly measure the transfer success of structural units on the basis of generated regular revenues without estimating the potential with the help of indicators. The amortization of knowledge transfer can take a long time depending on the commercialization channel and type of invention. A systematic monetary assessment of the transfer activities of all structural units, therefore, takes years after a professional transfer infrastructure has been established.

This research study strengthens the importance and public perception of knowledge transfer. Our approach can help universities to identify the existing transfer potential, and it delivers implications for a strategic realignment of policies. It contributes to the development of a professional evaluation system as required by politics (Becker et al., 2013; European Commission, 2011).

To further improve the estimation of the commercialization potential it is necessary to contrast research demand and offer. Hence, the next step in our research project will be a comprehensive investigation of the research demand of regional companies. At present, only few companies have information about the available technical infrastructure, the research foci and the research quality of local universities. From the political perspective, the current research is not sufficiently geared to the economic demand. Although we argue for a limited orientation, we are convinced that science and economy could profit from a closer connection and more transparency. Our future research will therefore explore discrepancies and show the potential to sustainably strengthen the economic power of a region.

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6. Appendix

Table 6: Overview of all structural units of the OvGU Magdeburg

Area	Faculty	Structural Unit
MINT	Electrical and Information Engineering	Automation Engineering
		Electronic Engineering and Signal Processing
		Electric Energy Systems
		Principles of Electrical Engineering
		Micro- and Sensor Systems
	Computer Sciences	Technical and Industrial Information Systems
		Knowledge and Language Processing
		Distributed Systems
		Simulation and Graphics
		SAP University Competence Center
	Mechanical Engineering	Engineering Mechanics
		Machine Design
		Manufacturing and Quality Management
		Industrial Science, Automation and Operation
		Logistics and Material Handling Engineering
		Mobile Systems
		Material Engineering and Joining Technology
	Mathematics	Algebra and Geometry
		Analysis and Numerics
		Mathematical Optimization
		Mathematical Stochastics
	Science	Theoretical Physics
		Experimental Physics
		Psychology II
		Biology
	Process and Systems Engineering	Fluid Engineering and Thermodynamics
		Process Engineering
		Process Technology and Environmental Studies
		Chemistry

Area	Faculty	Structural Unit
Social Sciences	Humanities	Vocational and In-company Training
		Educational Science
		Foreign language Philologics
		German Language and Language Studies
		History
		Philosophy
		Political Science
		Psychology I
		Sociology
		Sport Science
	Economics	Controlling
		International Management
		Corporate Tax
		Finance
		Leadership and Organization
		Production and Logistics
		Marketing
		Management Science
		Accounting
		E-Business
		Entrepreneurship
		Empirical Research in Economics
		Economics of Business and Law
		Innovation and Finance Management
		International Business
		International Human Resource Management
		Finance
		Theory of Economics
		Political Economy
		International Business
		Macroeconomics
		Employment Economics
		Civil, Trade and Business Law
		Money and Credit

Area/Faculty	Structural Unit
Medicine	Anatomy Physiology Medical Psychology Biochemistry and Cell Biology Neuro-biochemistry Molecular Biology and Medical Chemistry Pharmacology and Toxicology Clinical Pharmacology Social Medicine and Health Economics General Medicine Biometry and Medical Computer Science Clinical Chemistry and Pathobiochemistry Pathology Neuropathology Forensic Medicine Medical Microbiology Molecular and Clinical Immunology Transfusion Medicine and Immune Hematology with Blood Bank Human Genetics History, Ethics and Medical Theory Cognitive Neurology and Dementia Research General, Visceral and Vascular Surgery Accident Surgery Heart and Chest Surgery Neurosurgery Plastic, Esthetic and Hand Surgery Cardiology, Angiology and Pneumology Gastroenterology, Hepatology and Infectiology Stereotaxic Neurosurgery Nephrology, Hypertonia, Diabetology and Endocrinology Hematology and Oncology Experimental Internal Medicine Pediatric Clinic Neurology Psychiatry and Psychotherapies Child Psychotherapies Psychosomatic Medicine and Psychotherapies Radiology and Nuclear Medicine Neuroradiology Radiotherapy Orthopedic University Hospital Ophthalmic Hospital Urology and Child Urology Otorhinolaryngology Oral and Maxillofacial Surgery University Gynecological Hospital Reproduction Medicine and Gynecological Endocrinology Dermatology and Venerology Anesthesiology and Intensive Care Nephrology

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