The Dean in the University of the Future
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ECONOMIES OF SCALE AT FACULTIES

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Today, universities and faculties have become used to being analysed with performance or productivity measurement instruments. Methods have broadened and integrate qualitative and quantitative approaches. This research gives an overview regarding approaches to efficiency analysis in higher education. It asks how far efficiency is already a question for faculty management, includes a case study regarding faculty-based efficiency measurement for an example of 25 German economics and business administration schools and derives implications for higher education research and in particular for faculty management.

1. INTRODUCTION

Higher education efficiency has been traditionally an important research question, especially in relation to research productivity (Bottomley/Dunworth 1974; Barth/Vertinsky 1975; Banks, 1986; Alm et al. 1988; Cohn et al. 1989; Johns/Johns 1993; Ramsden 1994; Beasley 1995; Dundar/Lewis 1995; Hashimoto/Cohn 1997; Glass et al. 1998; Stahl et al. 1998). But during the last 15 years, this small and usually qualitative field of analysis within universities and faculties has been broadened in terms of methods and comparative international views as well as implications for the practice of higher education management in many countries (Madden et al. 1997; Ng/Li 2000; Jongbloed/Vossensteyn 2001; Khoronen et al. 2001; Feng et al. 2004; Johns 2006; Kocher et al. 2006; Kao/Hung 2008; Sarrico, 2010; Zangouiehrehad/Moshabaki 2011; Klumpp/Zelewski 2012).

Tight budgets impel public stakeholders as well as university leadership persons to ask for instruments for accountability which are often interpreted as performance or productivity measurement instruments. This research gives an overview regarding approaches to efficiency analysis in higher education (sections 2 and 3), including a case study regarding faculty-based efficiency measurement for an example of 25 German economics and business administration schools (section 4). It reports on some distinguished international findings and outlines the implications for higher education research and management.

2. EFFICIENCY AS A QUESTION FOR FACULTY MANAGEMENT

The efficiency or productivity of university and faculty operations has been a discussed and reported management question (Scholz Stein 2013) and is complex due to the very special nature of the university (and the faculties) as an organisational type and due also to the complexity of university and faculty outputs. Since the objective functions in higher education in the three areas of research, teaching and ‘third mission’ (often termed ‘transfer’, ‘outreach’, ‘community services’, see Zomer/Bennworth 2011, 82)
Economies of Scale at Faculties

contain a multitude of output indicators, possible productivity measurements are by
definition manifold.

Nevertheless, there are specific expectations regarding the output of universities, which can be expressed through equally
specific efficiency questions. Those questions are essential for university management
as many decisions taken within universities address resource allocation and are therefore directly connected to production
settings. Examples of such management questions linked to higher education decisions are depicted in table 1.

Table 1: Management Questions and Management Decisions Regarding Efficiency

<table>
<thead>
<tr>
<th>Management Question (Example)</th>
<th>Management Decision (Example)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research</td>
<td>Should specific research groups and faculty receive more funding? Should specific groups receive more management support?</td>
</tr>
<tr>
<td>Teaching</td>
<td>Should specific programmes be supported by advertising efforts or other forms of central resources? Should specific programmes be closed?</td>
</tr>
<tr>
<td>Third Mission</td>
<td>Should specific university or faculty co-operations be prolonged or ended?</td>
</tr>
</tbody>
</table>

The comparative view regarding several universities (or more seldom: faculties) has been established by research publications, e.g. Beasley (1995); Duddar-Lewis (1995); Glass et al. (1998); Ng/Li (2000); Kehrtten et al. (2001); Kocher et al. (2006); Kauf/Hung (2008) and Sarrico (2010). One of the latest data collection endeavors supporting a comparative international is the EU-MIDAS project supported by the European Commission, collecting for example staff, student and graduate data (Bonaccorsi et al. 2010).

3. EFFICIENCY ANALYSIS WITH THE DATA ENVIRONMENTAL ANALYSIS (DEA)

Methodologies used in measuring the efficiency of higher education operations have been manifold – and have interestingly many similarities to ranking endeavours in the output field. Table 2 provides a structuring overview regarding the basic categories (A to D) for performance and productivity measurement.

<table>
<thead>
<tr>
<th>Table 2: Comparison of Performance and Productivity Measurement Schemes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>One-dimensional Output Measurement</strong></td>
</tr>
<tr>
<td><strong>Performance Measurement</strong></td>
</tr>
<tr>
<td>(A) Simple Output Metrics, e.g.</td>
</tr>
<tr>
<td>- Number of graduates per university per year</td>
</tr>
<tr>
<td>- Number of reviewed publications per university per year</td>
</tr>
<tr>
<td>- Number of patents registered per university per year</td>
</tr>
<tr>
<td><strong>Input and Output Indicator Relation</strong></td>
</tr>
<tr>
<td>(C) Simple Productivity Metrics, e.g.</td>
</tr>
<tr>
<td>- Total teaching cost per graduate at one university</td>
</tr>
<tr>
<td>- Number of reviewed publications or citations in reviewed</td>
</tr>
<tr>
<td>- Amount of third party/industry income per Faculty head</td>
</tr>
<tr>
<td>- Total number of registered patents per 1 Mio. Euro (currency)</td>
</tr>
<tr>
<td>- University budget</td>
</tr>
<tr>
<td><strong>Multi-dimensional Output Measurement</strong></td>
</tr>
<tr>
<td>(B) Complex (Combined) Output Measurement Systems, e.g.</td>
</tr>
<tr>
<td>- Ranking systems as e.g. AR-WU, Leiden or Times Higher</td>
</tr>
<tr>
<td>- Performance-based funding systems with several indicators</td>
</tr>
<tr>
<td>- Stochastic frontier analysis for number of Faculty members</td>
</tr>
<tr>
<td>- Data envelopment analysis for university budget (input) and</td>
</tr>
<tr>
<td>- Data analysis for number of publications as well as number</td>
</tr>
<tr>
<td>- Data envelopment analysis for number of publications as well as number of patents (output)</td>
</tr>
</tbody>
</table>

The four depicted categories and their examples according to table 2 can be outlined in detail as follows:

(A) Simple one-dimensional outputs as performance measurements with just one output indicator are quite often used in higher education management and policies, e.g. for comparing universities (or departments thereof) regarding their number of graduates per year, or universities, faculties and even research groups regarding the number of publications, patent registrations or citations per year. For third mission activities, indicators such as number or turnover of spin-offs or the total number of their employees are used to measure performance on a university or faculty level.

(B) Usually, most university and even faculty ratings use a number of output indicators combined in relation to the specific objective of the ranking (see for example Van Vught/Ziegge 2012). For a ranking of teaching quality a combination of teacher-student-ratio, student satisfaction, international orientation and expert reputation might be used. For a research ranking a combination of industry income (third party funding), publications, citations and peer reputation might be used. The most commonly used method to calculate the overall score for such combined indicator rankings is weighted scoring systems, allocating each indicator a share out of a total of 100 per cent weighted distribution. All individual scores (with the same span of possible values e.g. from 0 to 100) are multiplied with their weighting and then added up to the total score.

(C) Simple productivity metrics usually operate with a relation between one output indicator (e.g. number of publications) and one input indicator (e.g. one researcher per one million Euro (currency) budget). Essential for the distinction between performance and productivity measurement (efficiency) is the inclusion of an input indicator, commonly addressed as the ‘size question’ (as usu-
ally performance indicators favour larger institutions or units which (easily) reach higher output numbers for example in terms of graduates or publications numbers. Though the division of output numbers by input numbers is used most often, theoretically also the division of inputs by outputs is feasible and may also yield interesting insights: For example the question of what budget has been spent on average to recruit one student or graduate or achieve one publication.

(D) For the inclusion of multiple input and multiple output indicators, a number of methods are available in order to calculate a measurement result; the two most commonly used ones are stochastic frontier analysis (SFA) and data envelopment analysis (DEA):

(i) SFA: The stochastic frontier analysis uses a given production function in order to calculate productivity measures from the input and output data (Aigner et al. 1977; Kumbhakar/Loeffl 2000). If such a production function is known this is a very feasible method, as it indicates clearly the improvement potential for all non-efficient units (Jacobs 2001; Cullinane et al. 2006; for universities see for example: Stevens 2005). But if there is no known production function for all relevant inputs and outputs this is less valuable though assumptions may be made (Coelli 1995).

(ii) DEA: The data envelopment analysis was proposed in 1978 and developed further as a non-parametric multi-criteria efficiency measurement method (cf. Charnes et al. 1978; Charnes et al. 1991; Seiford 1996; Fedjaia-Chaparro et al. 1997; Cooper et al. 2000; Klein 2004; Zhu/Cook 2007; Thanassoulis et al. 2008). It is commonly used in multi-dimensional output industries such as service industries (health care: Butler/Li 2005, ecological analysis: Dyckhoff/Allen 2001) and also higher education (i.e. McMullan/Datta 1998; Taylor/Harris 2004; McMullen/Chan 2006).

Existing criticism regarding the different fields of measurement usually addresses the following areas: It is acknowledged that single output indicators naturally cannot depict the complex task of a university, especially since they do not take into account the distinction between the objective areas of research, teaching and third mission, neglecting the Humboldt Principle of an assumed or desired unity of these areas within universities as a founding principle. Additionally with just one output measure no the size of the higher education institution is crucial: larger universities have a comparative advantage in this perspective (Matthew Effect). From these typical critical arguments it is obvious that in developing adequate measurement and comparison systems in higher education the tendency should be directed towards systems in Category D with simultaneous multiple input and multiple output measurements. The methodology options in this last field are outlined further in the next section in the form of a small case study of faculty efficiency.

4. FACULTY EFFICIENCY CASE STUDY

In order to connect a current and relevant efficiency example regarding faculty efficiency, data for 25 German faculties for economics and business administration are analyzed. A data envelopment analysis (DEA) studies different Decision Making Units (DMUs), the definition of which is rather open in order to guarantee flexibility in the term’s application. In order to ensure relative comparisons, different DMUs are evaluated and compared with each other, each DMU showing a specific level of managerial effort and decision-making success. Based on the latest Handelsblatt Ranking 2013 in Germany (number of professors as input and publication points for journal publications as output; Handelsblatt 2013) and the research funding data from the German DFG (competitive research funding grants from DFG as output; DFG 2013) an efficiency analysis is carried out (see table 3 below). For the seven universities in Austria and Switzerland incorporated in the Handelsblatt ranking but without data from DFG (only German – public – universities are eligible for funding) an efficiency calculation was not possible.

<table>
<thead>
<tr>
<th>University</th>
<th>Prof.</th>
<th>DFG 2009-2010 in Mio. €</th>
<th>Publication Points</th>
<th>Efficiency Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aachen RWTH</td>
<td>12</td>
<td>353,812,55 €</td>
<td>42</td>
<td>99,20%</td>
</tr>
<tr>
<td>Augsburg Uni</td>
<td>14</td>
<td>445,889,07 €</td>
<td>30</td>
<td>60,40%</td>
</tr>
<tr>
<td>Berlin ESMT</td>
<td>10</td>
<td>0,00 €</td>
<td>35</td>
<td>100,00%</td>
</tr>
<tr>
<td>Berlin FU</td>
<td>17</td>
<td>2,701,107,21 €</td>
<td>30</td>
<td>70,50%</td>
</tr>
<tr>
<td>Berlin TU</td>
<td>11</td>
<td>875,591,94 €</td>
<td>30</td>
<td>80,20%</td>
</tr>
<tr>
<td>Bonn Uni</td>
<td>31</td>
<td>5,033,319,83 €</td>
<td>25</td>
<td>82,10%</td>
</tr>
<tr>
<td>Darmstadt TU</td>
<td>9</td>
<td>59,266,42 €</td>
<td>30</td>
<td>97,80%</td>
</tr>
<tr>
<td>Duisburg-Essen Uni</td>
<td>28</td>
<td>850,289,71 €</td>
<td>36</td>
<td>43,20%</td>
</tr>
<tr>
<td>EBS Uni</td>
<td>26</td>
<td>0,00 €</td>
<td>42</td>
<td>49,40%</td>
</tr>
<tr>
<td>Frankfurt/Main Uni</td>
<td>27</td>
<td>1,486,697,92 €</td>
<td>70</td>
<td>83,70%</td>
</tr>
<tr>
<td>Frankfurt School of Finance and Man.</td>
<td>28</td>
<td>0,00 €</td>
<td>44</td>
<td>51,80%</td>
</tr>
<tr>
<td>Giessen Uni</td>
<td>6</td>
<td>124,494,1 €</td>
<td>15</td>
<td>100,00%</td>
</tr>
<tr>
<td>Graz Uni</td>
<td>15</td>
<td>0,00 €</td>
<td>34</td>
<td>-</td>
</tr>
<tr>
<td>Hamburg Uni</td>
<td>32</td>
<td>278,261,45 €</td>
<td>68</td>
<td>80,00%</td>
</tr>
<tr>
<td>Hannover Uni</td>
<td>11</td>
<td>843,168,76 €</td>
<td>26</td>
<td>69,80%</td>
</tr>
<tr>
<td>Innsbruck Uni</td>
<td>15</td>
<td>0,00 €</td>
<td>46</td>
<td>-</td>
</tr>
<tr>
<td>Jena Uni</td>
<td>10</td>
<td>1,430,750,02 €</td>
<td>33</td>
<td>100,00%</td>
</tr>
<tr>
<td>Kiel Uni</td>
<td>8</td>
<td>875,238,69 €</td>
<td>14</td>
<td>100,00%</td>
</tr>
<tr>
<td>Koblenz/Vallendar WHU</td>
<td>25</td>
<td>0,00 €</td>
<td>55</td>
<td>64,70%</td>
</tr>
<tr>
<td>Köln Uni</td>
<td>25</td>
<td>1,625,446,88 €</td>
<td>68</td>
<td>81,60%</td>
</tr>
<tr>
<td>Köln Logistics Uni</td>
<td>6</td>
<td>0,00 €</td>
<td>18</td>
<td>100,00%</td>
</tr>
<tr>
<td>Magdeburg Uni</td>
<td>12</td>
<td>247,446,60 €</td>
<td>24</td>
<td>56,80%</td>
</tr>
<tr>
<td>Mannheim Uni</td>
<td>24</td>
<td>6,129,920,61 €</td>
<td>78</td>
<td>100,00%</td>
</tr>
<tr>
<td>München LMU</td>
<td>22</td>
<td>4,622,675,13 €</td>
<td>69</td>
<td>94,80%</td>
</tr>
<tr>
<td>München TU</td>
<td>23</td>
<td>746,163,98 €</td>
<td>85</td>
<td>100,00%</td>
</tr>
<tr>
<td>Münster Uni</td>
<td>18</td>
<td>756,286,40 €</td>
<td>33</td>
<td>51,50%</td>
</tr>
<tr>
<td>St. Gallen Uni</td>
<td>44</td>
<td>0,00 €</td>
<td>118</td>
<td>-</td>
</tr>
<tr>
<td>Wien Uni</td>
<td>16</td>
<td>0,00 €</td>
<td>91</td>
<td>-</td>
</tr>
<tr>
<td>Wien Bocconi</td>
<td>45</td>
<td>0,00 €</td>
<td>87</td>
<td>-</td>
</tr>
<tr>
<td>Würzburg Uni</td>
<td>10</td>
<td>154,300,00 €</td>
<td>18</td>
<td>52,00%</td>
</tr>
<tr>
<td>Zürich ETH</td>
<td>12</td>
<td>0,00 €</td>
<td>63</td>
<td>-</td>
</tr>
<tr>
<td>Zürich Uni</td>
<td>27</td>
<td>0,00 €</td>
<td>89</td>
<td>-</td>
</tr>
</tbody>
</table>
5. CONCLUSION

It has to be emphasised that for management implications and decisions, further analysis of all efficiency measurements is needed in order to understand the complex connections regarding productivity in university operations. Detailed analytical approaches should address the interaction of research and teaching as well as other success factors for university operations such as location and regional networks, gender issues, leadership and organisational matters. From the outlined case study as well as previous research regarding university efficiency the following implication areas and hypotheses may be derived:

- No empirical evidence for economies of scale can be found (hypothesis not falsified but increasing probability for a dis-economies of scale hypothesis).
- Possible reasons and influences may be coordination efforts, increasing "mission diversity" and "mission creep" with institutional size.
- A positive view may see that benchmarking reveals efficiency potential in most settings and analyses - for all subgroups (large/small, private/public).
- The efficiency view may be a complementary and necessary (new) perspective. For the practical faculty management context, some implications can be named as additional hypotheses:
  - Faculties shall cease from "size matters" strategies - or use this only in very cautious applications, i.e. only with "checks and balances".
  - Faculties shall rethink objectives, strategies and excellence concepts - in combination with "quality profiling", because otherwise efficiency measurement has no real meaning.
  - Faculties shall make "excess costs of excellence and size" internally visible in institutions (and also provide "fair" cost allocation).

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Economics of Scale at Faculties


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