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Empirical observations on New Public Management to increase efficiency in public research—Boon or bane?

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ABSTRACT

New Public Management (NPM) was the catch phrase of the reforms in the public research and higher education sector for the last decades. The postulated effect of the NPM reforms is increased efficiency in governmental resource spending on the public higher education and research institutions. Though backed by theoretical considerations, this hypothesis has hardly been tested empirically. Using a unique dataset of German research units, this paper deals with the influence that NPM mechanisms have on research performance. Controlling for different university mission, it can be shown that both greater internal hierarchy (especially "strong presidents") as well as greater operative flexibility for the researchers themselves increase research performance. Some of the variables, including the presence of research councils, have a positive effect on research efficiency under some definitions of research output. On the other hand, the introduction of resource accounting systems has a negative impact. All in all, we conclude that the public science sector reforms implemented in most of the Western economies were heading into the right direction by providing greater performance incentives and increasing allocative efficiency in resource spending. Also we provide some ideas of how NPM may be combined in order to construct a sensible governance system. We conclude that the mechanisms should be selected based on the mission of the university.

1. Introduction

In many western countries, profound changes have taken place in the organisation of the public science systems (e.g. de Boer et al., 2007; Meyer, 2007; Frolich, 2005; Smith, 2004). Although the countries started from very different positions, the governance schemes converge towards a pattern that is often described as New Public Management (NPM) (Leisyte and Kizniene, 2006). In contrast to the organisational systems which were common in many continental European countries such as Germany, France, and Austria, the spirit of NPM consists of two pillars (Braun and Merrien, 1999; Schimank, 2007a,b). First, the decision-making competencies of the state authorities are reduced, especially at the purely operative level, leaving much greater steering autonomy to the researchers. Second, the internal hierarchy is strengthened, that is to say, the management authorities (the deans and the university presidents) gain much greater power over the researchers. Many different mechanisms were developed to deploy the new governance structures in practice. Among these are resource controlling, global budgeting, goal agreements, performance-oriented budgeting by indicators, or performance-oriented payment schemes. In any case, though NPM is *en vogue* among European policy-makers, to our knowledge, there is little empirical proof that the new governance system indeed results in efficiency gains. Indeed, its benefits are sometimes implicitly doubted, because it is argued that research is not a routine task and the most empowering setting is that of academic freedom. Anyhow, the latter claim has not been proven either. A lot of researchers also claim that the concept of efficiency does not even apply to the science sector, where, however, rarely it is made explicit, what efficiency means. To place it right here, econometric efficiency analysis has developed a clearly defined concept of efficiency, which is also explained in Section 3.2. One implication of this concept is that a unit which is more efficient than another is able to gain higher outputs from a given level of input. Particularly this implication makes the concept of efficiency so appealing for politics, because it allows increasing societal gains from the science sector by increasing efficiency, without having to increase inputs. NPM certainly is the most discussed – though disputed – concept to increase efficiency.

Using a unique dataset of a large sample of German research units gathered during a project on "international competitiveness and innovation capacity of universities and research institutions—new forms of governance" funded by the German Research Association (Deutsche Forschungsgemeinschaft, DFG), we

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will present concise results which point to positive effects of the typical NPM mechanisms on research performance.

2. New Public Management—it is not just hot air

As already mentioned, NPM is a fashionable concept, especially in politics. Therefore, although it has a large number of academic proponents, it has been criticised as one more slogan voiced by governmental authorities to organise a silent phasing out of state funding of public research. On the contrary, the proponents argue that the most successful science nations – the UK and USA – have adopted such a system and therefore regard it is beneficial. Despite this heated atmosphere, it is not only legitimate but also necessary to ask what the essence of NPM actually is, and where the postulated efficiency gains should accrue from.

In fact NPM is more than just a slogan. Its theoretical roots date back to two distinct branches of economic theory. The first is that of property rights (see e.g. Demsetz, 1967; Buchanan, 1984), where although this theory is a lot broader, one if its implications is that the separation of ownership (in this context the societal resources devoted to research) and control (in this context the resources controlled by the researcher) leads to efficiency losses. The contribution of the property rights theory is therefore that a property right has many dimensions (Kim and Mahoney, 2005); in this case, the right of ownership, which allows collecting the returns, and the right of control. The second pillar is principal agent theory (see e.g. Jensen and Meckling, 1976; Holmstrom, 1979; Bolton and Dewatripont, 2005 as a recent overview), which states that if the principal (in this context the society or the state authorities) cannot observe the agent's effort level (in this context the researchers), then the agent tends to work too little, where he would argue that possible failure has to be accrued to bad luck and not to laziness. This is known as moral hazard.

A decisive question is of course, whether any of the two theories actually applies to research as such. This seems to be especially important, because both theories have not been developed to describe the university system but were tailored to more "economic" situations.

Concerning the property rights theory, the key result is that the distribution of property rights has effects on efficiency. In the particular case of universities, property rights theory argues for a principal–agent situation, where the principal has the ownership rights and the agent controls the resources. That this is a characterising feature of public research is obvious. Letting the principal be the society and the agent be the researcher, society gives resources (incurred by taxation) to the researchers (basic funds and research grants). Although the knowledge produced by researchers may be published exclusively by them, usually they are not owners of the economic benefits resulting from the knowledge: a mathematician may not patent a formula. A patent resulting from a researcher's invention usually is owned by the university (in this sense the state) and not by the researcher. Thus the society is still the owner of the economic returns of research. Using for example arguments such as moral hazard, then it follows directly, that institutions characterised by a separation of control and ownership rights are less efficient. Thus, we need an argument on why moral hazard is important also in science.

The key result of moral hazard is that unobservability of the agent's effort level induces incentives to work too little, which is rational because effort is linked to disutility, i.e. additional effort induces additional costs to the agent. In some cases this is a natural assumption, but it need not be true for researchers. It is commonly argued that researchers are intrinsically motivated, and thus the central assumption of efforts inducing disutility may be violated. Thus, if effort induced utility rather than costs (because the researcher likes his work), moral hazard would no longer be a problem. However, is it likely that researchers are always and everywhere intrinsically motivated, invalidating the problem of moral hazard? This certainly depends on the specific task. While it seems reasonable to assume, that researchers are highly motivated to conduct original research, this might not be true many other activities linked to research, such as educating doctoral students, engaging in knowledge transfer, or editing journals and reviewing articles. It might well be true, that these activities are subject to moral hazard, although doing genuine research might not. Therefore, we suspect that moral hazard is a problem – at least partly – also in the science sector.

Bearing both lines of argumentation in mind, it is easy to understand the spirit of NPM. In any case, it is helpful to contrast the pre-NPM system in Germany and New Public Management, because in a certain sense, both are inverted mirror images. This can be seen most easily, by using the 'equalizer'-model of Schimank (2007b). He argues that, in essence, there are 5 governance dimensions, whose specific importance can describe each university system. Therefore, each constellation of the 5 so-called 'sliding controllers' describes a different university system. Any of these constellations can be thought of as a specific setting on an equaliser, giving a particular tune. The first of the 'sliding controllers' is the level of *state regulation*. This mechanism determines the strength of the governmental influence. The second concerns *external control* through governmental or societal stakeholders, often in the form of research councils (not to be confused with funding councils in the UK), which are similar to a directorate in a company (Mayntz, 2002). The third is *academic self-management* which measures the degree to which the chair holders can decide autonomously. The fourth is *internal hierarchical self-control* mapping decision competencies of the deans and chancellors inside the university. The fifth is *market control* often induced by the increasing need to acquire external funds.

The old German public science system is characterised by large competencies of the state authorities in regulation of operative management decisions as well as high competencies of the individual chair holders in setting their research and teaching agenda. Cynically, one could remark that this setting may be described as a mixture of command economy and provincial principalities not unlike the state organisation in USSR before 1991. All other governance mechanisms did not play a major role.

NPM is exactly the opposite: high degree of control by external stakeholders, of internal hierarchical control, and of market control in conjunction with a low degree of state and chair holder competencies.

By introducing NPM in German universities, which is still an ongoing process, the foremost aim of the state authorities was to increase efficiency in research and teaching.

Four potential sources of efficiency gains from NPM may be identified, which will also guide our empirical design. The first, and most obvious, is to increase operative flexibility of the universities. In theory, this should make resource allocation more efficient, because the decision process is made faster and more problem-oriented (subsidiarity). However, increasing operative flexibility ceteris paribus reduces accountability, therefore resources may be used in a manner not in accordance with societal goals. Thus, NPM aims at increasing accountability by strengthening internal hierarchical elements, most prominently, the influence of the deans, the chancellors, and the presidents. This second source of efficiency gains might result from a decreased danger of moral hazard (see above). The third is to give the decision-making units feedback and information on their actions. Often this can be achieved by the introduction of internal accounting models. The fourth is to enhance competencies concerning strategic decisions. This once again can be achieved by greater internal hierarchy but also by the newly installed research councils which shall guide, advise, and also

Table 1
Description of the variables and summary statistics.

Variable	Shorthand (if used)	Time period	Unit/type	Mean	S.D.	Min	Max
Research outputs							
Fraction of time spent on third party research		2004–2005	Percent	69.16	28.91	0	100
Advisory service for companies		2004–2005	Count	0.56	1.44	0	11
Cooperations with companies		2004–2005	Count	2.05	3.46	0	26
Conferred doctoral titles		2004–2005	Count	4.25	4.86	0	52
Conferred state doctoral titles		2004–2005	Count	0.50	1.07	0	13
Number of publications in the SCI/SSCI-database		2004–2006	Count	31.47	40.78	0	320
Number of citations in the SCI/SSCI-database		2004–2006	Count	118.82	177.73	0	1359
Research inputs							
Number of scientists excluding PhD students		2005	Count	6.68	8.48	1	77
Number of scientists including PhD students		2005	Count	14.47	14.18	1	129
Age of computers when replaced		2005	Count	4.54	1.37	2	10
NPM governance variables							
Existence of personnel quotas	PERSONNEL	2006	Binary	0.80	0.40	0	1
Perceived de facto influence of the deans	DEANS	2006	1–5 Likert Scale	3.20	1.02	1	5
Perceived de facto influence of the presidents	PRESIDENTS	2006	1–5 Likert Scale	3.65	0.97	1	5
Existence of goal agreements	GOAL	2006	Binary	0.30	0.46	0	1
Existence of an accounting scheme	ACCOUNT	2006	Binary	0.53	0.50	0	1
Existence of research councils	COUNCIL	2006	Binary	0.70	0.46	0	1
Existence of regular evaluations	EVAL	2006	Binary	0.39	0.49	0	1

decide on items concerning the university as a whole. This might contribute to research efficiency as it sets out an overall agenda for the departments and the university as a whole.

As mentioned above, the goal of this paper is to test for positive impact on research efficiency of university chairs coming from any of these sources. In the next section we will briefly describe the dataset.

3. Empirical discussion

3.1. Dataset

During February and March 2007 an online survey of German research units at the micro-level was performed. In a lengthy process we were able to identify 1908 university chairs and corresponding extra-university units from the disciplinary fields of astrophysics, nanotechnology, biotechnology, and economics. Choosing this particular set of disciplines was inspired by a most dissimilar case design (for further discussion see Schmoch and Schubert, 2008). The first divide is along the dimension of natural sciences (astrophysics, bio- and nanotechnology) vs. social sciences (economics). However, the second divide is along the dimension of basic (astrophysics, economics) vs. applied research (bio- and nanotechnology).

Until March we received 473 valid answers (astrophysics: 34, nanotechnology: 201, biotechnology: 136, economics: 102), which implies a participation rate of almost 25%. 140 of the answering units were (public) extra-university belonging to institutions such as the Max Planck or the Fraunhofer Society. The remaining 333 were from universities.

In this paper, we will focus on the latter group, mainly for two reasons. First, extra-university units did not have to cope with state authority interference in the past to the same extent as the universities. Therefore, they already had much greater steering autonomy in the past. The very recent policy changes, which are at the focus of this paper, are directed primarily towards the university units. Thus if New Public Management shall be linked to research efficiency, it seems more adequate to restrict the analysis to universities. Second, the extra-university public science sector in Germany is highly fragmented. This heterogeneity might be hard to deal with econometrically.

In this online survey, questions were asked concerning inputs like number of scientists, quality of capital equipment, etc. as well as concerning outputs including publications[2], editorships, cooperation with companies, etc. In addition, questions concerning the governance structures were asked, including the existence of rigid personnel quotas or existence of management accounting systems. Also, we were interested in the perceived power of the deans or the chancellors. By this design we were able to link relationships between inputs and outputs (more specifically efficiency) to governance structures, which is the foremost objective of this paper.

The variables used throughout this paper are described in Table 1. Summary statistics are given. In fact, these are only a snapshot of the 64 variables asked for in total. Without going into detailed analysis, we see that there is great variety among the research groups. For example, the smallest consists of just one person while the largest has a size of 129 scientists including PhD students. The maximum number of publications of the single research institute is 320 and the minimum number is 0. Some groups do not conduct any third party research, while others have a share of 100%. Some interesting facts can be seen from the NPM variables. About 80% of the research groups still have to face rigid personnel quotas. About 40% are regularly evaluated. 53% control their resource movements via some form of accounting model. 70% have research councils at their universities. In any case, important for our purpose is the fact that the variety does note solely relate to structural figures describing the research unit itself, but also to the governance structures they operate under, i.e. while some research units are still subject to the traditional German governance scheme, others operate under almost purely NPM structures. Some will be located in transitional systems. More details on this are given in Section 4, where the research units are classified according to the instruments they have introduced. This heterogeneity allows us to estimate the effect of different NPM tools on research performance via cross-section data.[3] In the next section we describe the

[2] Apart from the self-reported numbers of publications, for almost all units we determined the persons belonging to the units. So we were able to use bibliometric indicators coming from the Web of Science like SCI/SSCI publications as well as citation rates and international co-publications. In the following we use the bibliometric indicators from the ISI database instead of the self-reported results.

[3] Clearly panel data would have been more desirable. Especially, it would allow us to estimate diffusion or indirect effects. It might be for example be possible that

testing methodology adopted, as it guides some of the following discussions.

3.2. Methodology

As we would like to determine the efficiency effects of NPM, the methodology basically consists of calculating multidimensional efficiency measures and then of regressing them on NPM governance variables in order to detect significant effects exerted by the governance model. This will be done in a multivariate regression model. This basic idea, which should be kept in mind, is in fact simple. However, there are a lot of statistical trap holes involved. How these can be dealt with, is explained in this subsection. Since this discussion entails many statistical subtleties, this section is somewhat technical. In any case, reading this chapter is not necessary for understanding the results of Sections 3.5 and 4. Therefore, the readers more interested in the results may skip this subsection.

In order to test for positive effects of NPM on research performance, an estimate or an indicator of research performance must be obtained. This is not as trivial as it may seem. Many authors recognise, at least implicitly, that research performance is multidimensional (e.g. Rousseau and Rousseau, 1997; Nagpaul and Roy, 2003; Warning, 2004; Johnes, 2006). Also, it is known from prior work that research units specialise in very diverse activities (Larédo and Mustar, 2000; Jansen et al., 2007). Therefore using a single indicator (such as publication counts) as a proxy for research performance will not prove useful, because the results will be distorted in favour of those units specialised in the activity covered by the specific indicator use. Instead we calculated FDH scores[4] as a measure of efficiency for different sets of inputs and outputs, in a first step, and tried to test for partial correlations of these scores with NPM variables in a second-stage regression. Let us first have a closer look on the concept set by FDH estimation.

The FDH estimator (compare Deprins et al., 1984) is similar to the DEA estimator (Farrell, 1957; Charnes et al., 1978) of technological efficiency except that convexity of the production set is not imposed. Because we do not know if the production frontiers in research exhibit non-increasing returns to scale, we regard it as safer to use the more flexible FDH efficiencies, which are consistent under any shape of the production frontier.

More formally, letting Ψ be the set of feasible input-output relations, then the FDH estimator of this production set is defined as

$$\widehat{\Psi}_{FDH} = \{(x,y) \in \mathbb{R}_+^{p+q} | y < y_i, x > x_i, \quad (x_i, y_i) \in \chi\} \tag{1}$$

where x is p-dimensional input-vector, y is a q-dimensional output-vector and χ is the set of observations. Letting $D_0 = \{i \,|(x_i, y_i) \in \chi, x_i \leq x_0, y_i \geq y_0\}$ the set of indices of units dominating unit 0, then it can be shown that the input-oriented FDH efficiency estimator can be calculated as:

$$\widehat{\vartheta}(x_0, y_0) = 1/\hat{\beta} = \frac{1}{\inf\{\beta | (\beta x_0, y_0) \in \widehat{\Psi}_{FDH}\}} = \left(\min_{i \in D_0} \max_{j=1,\ldots,p} \left(\frac{x_i^j}{x_0^j} \right) \right)^{-1} \tag{2}$$

This mathematical representation looks complicated and is certainly not intuitive. However, having a look at the graphical interpretation, makes things a lot easier. We focus on the output orientation, because it is easier to understand than the input-oriented measure in Eq. (2). However, the principle is the same.

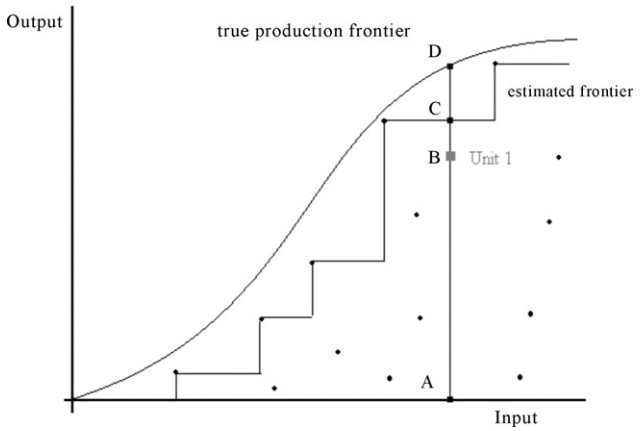

Fig. 1. The concept of FDH estimation.

Suppose that there is only one input and one output. The production frontier is defined as the maximum possible output that can be produced with a given input level, i.e. any unit be below or at most on frontier. A natural way to define efficiency would be to measure the distance of the unit's location from the production frontier. Taking Fig. 1 the (output oriented) efficiency measure attributed to Unit 1 (gray shaded square) would be the distance the |AB| divided by the distance |AD|. The problem is of course, that the production frontier is not observed. Thus it must be estimated, where we assume that we have a sample of observed units. The FDH procedure constructs an estimated frontier out of the sample. What FDH does in particular is setting up a step function that envelops all points that are not dominated by any other unit in terms of inputs and outputs. Now, once this frontier is constructed – the mathematical definition is given in equation (1) – the estimated efficiency measure for Unit 1 can be calculated as |AB|/|AC|.[5]

In order to test for the effects NPM may have on efficiency, it seems reasonable to run a regression where the previously estimated efficiency score will be explained by NPM variables describing the governance model. The first estimation technique that comes to mind is therefore a two-stage approach, where in a first step FDH scores are calculated on then in a second step are regressed on the NPM variables using ordinary least squares (OLS).

Although the general estimation spirit is good (and some authors have followed exactly that strategy), without corrections it is statistically flawed. Simar and Wilson (2007) show that there are at least two points regarding special attention, both being linked to the nature of the FDH estimates. First, FDH scores may take values of 1 or above, i.e. they are bounded from below. Thus, usual OLS regression will therefore result in inconsistent estimation. Second, the FDH scores are estimates themselves and are not simply surveyed variables. Therefore, they are subject to estimation error, which will usually affect the estimation process of the second-stage regression.

The first problem is usually accounted for in the literature, by running a Tobit regression model, which corrects for problem of a bounded explanatory variable. Anyhow, Simar and Wilson (2007)

research units, although still operating under the old regime, are affected indirectly, because many other units work under the new regime, which would change the implicit logic of the science system into a more efficiency-oriented one. This effect cannot be checked with cross-section data only.

[4] The FDH scores for each research unit were calculated with reference only to the own disciplinary peers to account for field-specific differences in the production technology.

[5] Note a peculiarity: Since all units can at most be on the true production frontier, but usually will fall short of it, efficiency is always overestimated in finite samples. However, as more and more units are observed, the likelihood is large that there are many units close to the true frontier. Thus the estimated frontier converges to the true. Also note that this measure is smaller than 1, while the input measure in Eq. (2) is >1.

argue that the Tobit specification is rather crude and conceptually misguided, because it does not reflect the properties of the underlying data generating process, which has – by assumption – a continuous distribution (instead of mass-points) at the frontier. Using a Tobit specification rather reflects finite sample problems of the FDH estimator than the characteristics of the density close to the frontier itself. They argue that the correct model is a truncated regression model. Using the Tobit model rather than the truncated regression, results in severe small sample bias, which vanishes only in large samples.

The second problem of error in the FDH estimates has been disregarded completely by the literature. Thus, regressing the FDH scores on explanatory variables as if they were observed is common to the literature. Not accounting for the estimation error results in invalid statistical inference in the second-stage regression, since the usual standard errors will no longer apply. This problem pertains even if the sample size is large.

In summary, using Tobit instead of truncated regression may induce finite sample bias in the coefficients. Treating FDH or DEA scores as if they were observed results in flawed inference, which does not vanish even in large samples.

Now, what can be done about the flawed statistical inference? To obtain valid inference Simar and Wilson (2007) propose complicated bootstrap algorithms in the second-stage truncated regression. Because the derivation and is very technical, we will not go into more details. The interested reader is referred to this reference. We applied algorithm #1 described in their article. For any of the regressions performed 1000 bootstrap replications were used.

3.3. Definition of research output and input

As research output is sometimes proxied only by bibliometric indicators, one objective of this survey was to be very broad in the definition of what research output actually is.

All in all, we collected 12 output measures, where 5 belonged to the knowledge and reputation generating section (publications, citations, conference articles, international co-publications, professorial job offers), 3 belonged to interaction with business and governmental bodies (advisory services for companies, cooperation with companies, membership in advisory boards), and the remaining 4 belonged in the maintenance dimension (number of doctoral titles, number of state doctoral theses, editorships, and scholarships).

In prior work (Jansen et al., 2007) we found four types of units with distinct output-profiles concerning research, that is to say, research units specialise in certain activities by choosing specific output bundles. The typical units found are those that publish many papers, those that write not as many but highly cited papers, those that engage in graduate teaching, and those that engage in transfer activities such as cooperation with companies or memberships in scientific advisory boards. We therefore have some indication which output indicators should be included in order to measure output.

However, because universities are pushed to develop unique agendas and profiles (Enders, 2001) this balanced scheme may not provide the only reasonable output definitions. Some university profiles may emphasise graduate teaching while giving not as much weight to publications. Others, in turn, may have a focus on technology transfer to companies.

Because the influence of NPM mechanisms may differ as the notion of output changes, I defined four different output bundles, which are, to a certain extent, inspired by our prior work (Jansen et al., 2007) and our prior expectation (reputation, transfer, and maintenance). The one linked to that most directly is what we called the balanced set, because for each dimension identified (see above) one corresponding variable (or one composite of variable) was picked to cover this dimension. The other sets are derived from this balanced definition simply by including one additional variable from one specific dimension to replace that of another. By this procedure the balanced scheme is biased towards a specific direction (e.g. graduate teaching).

Despite the fact that one of our main results (Jansen et al., 2007) was that third party funds are detrimental to publication and basic research activities under certain conditions, this variable was included in the remaining three output sets. This was done not because we believe that it is a good output indicator, but because many university managers, and especially the state authorities, believe that it is. Therefore it is used widely in Germany (Orr et al., 2007; Jäger et al., 2005; Jäger, 2006a; Leszczensky and Orr, 2004).

3.3.1. The balanced scheme

The balanced output set includes the variables publications, fraction of time spent on third party research as a proxy for third party funds, number of advisory services for companies plus number of cooperations with companies, and conferred doctoral plus state doctoral degrees. The balanced scheme is defined as a set of output indicators consisting of the dimensions highlighted in the following three sets without giving special weight to any.

3.3.2. The transfer-oriented scheme

The variables included are fraction of time spent on third party research as a proxy for third party funds, number advisory services for companies and number of cooperations with companies as separate dimensions, and conferred doctoral plus state doctoral degrees. This output definition highlights the task of technology transfer to companies.

3.3.3. The graduate teaching-oriented scheme

The variables included are fraction of time spent on third party research as a proxy for third party funds, conferred doctoral and state doctoral degrees as separate dimensions, and number of advisory services for companies plus number of cooperations with companies. By using this set of output indicators, the focus is set on the task of education and qualification.

3.3.4. The publication-oriented scheme

The variables included are number of publications, number of citations per publication as a measure for impact, number of advisory services for companies plus number of cooperations with companies, and conferred doctoral plus state doctoral degrees. This output definition is dominated by the task of conducting basic research as measured by bibliometric indicators.

We did not make a distinction concerning inputs. These were defined to be the number of scientists (excluding doctoral or PhD students) and the inverse of the average age of the computers when replaced in that unit as a measure of the quality of capital stock. Unfortunately, the monetary value of the capital stock proved to be largely unknown to the research group leaders. This was the best still objective measure we could think of.

3.4. Ex ante hypotheses

Referring to the discussion in Section 2, four sources of potential efficiency gains were identified. In this section we will revisit this theoretical discussion and operationalise the dimensions with variables from the survey. Additionally, we give the ex ante expectation on the estimated coefficient resulting from the notion of NPM theory.

3.4.1. Increasing operative flexibility

I use a single variable for this dimension, namely the non-existence of strict personnel quotas (PERSONNEL—0 if false and 1 if true). Binding personnel quotas reduce the flexibility of the research units. Bearing in mind that higher input-oriented FDH scores imply lower efficiency—so to say, they are rather of measure of inefficiency, NPM would predict a negative coefficient for the regression model.

In fact, other questions concerning operative flexibility, such as fraction of resources that can be spent freely, were asked. However, it turned out that few research units were familiar with this data. Therefore the item non-response was high and the quality of the answers may be doubted. Therefore, I decided not include these variables.

3.4.2. Increasing short- to mid-term accountability

For this dimension I use three variables. The first two are perceived strength of the de facto exerted influence of the deans (DEANS, 1–5 Likert scale, 1 very low and 5 very high) and perceived strength of the de facto exerted influence of the chancellors and presidents (PRESIDENTS, 1–5 Likert scale, 1 very low and 5 very high). As NPM says that increasing the power of those in charge implies higher efficiency, because losses due to moral hazard are reduced, I expect both coefficients to be negative.

The third concerns existence of goal agreements (GOAL, 0 if false and 1 if true). Goal agreements can be thought of as a treaty between the research unit and usually the deans, in which both parties agree on some objective to be accomplished over some time horizon. Since this is a tool to steer the activities of the research units, once again NPM predicts a positive impact and the coefficient should be negative.

3.4.3. Resource control and feedback

I use one variable to cover this field, which is the existence of an accounting system monitoring the resource movements of the respective research unit (ACCOUNT, 0 if false and 1 if true). The coefficient is expected to be negative.

3.4.4. Increasing long-term strategic capabilities

Two variables are used to cover this field. The first is the existence of a research council at the university of the research unit (COUNCIL, 0 if false and 1 if true). The second is if the research unit is evaluated regularly (EVAL, 0 if false and 1 if true). EVAL is included in the fourth block because evaluations tend to aim at the long-term strategic orientation of the research units. Therefore research councils set an agenda for departments and universities and evaluations – at best – pass on these decisions to the research units. Following NPM both mechanisms should increase research efficiency and the coefficients should be negative.

3.5. Estimation results

As noted in Section 3.2, to test the influence of NPM on research efficiency, a semi-parametric approach was employed where FDH scores are calculated in a first step and, in a second step, and the FDH efficiency scores are regressed on the NPM variables described in the previous section. As noted in Section 3.3, different sets of output variables were used to determine if the influence of NPM fluctuates as the definition of output changes. The results of this estimation can be found in the following table, where the regressions run are multivariate.[6] Therefore, the coefficients indicate the influence of the different NPM mechanisms controlling for all other mechanisms simultaneously.

We did not include field dummies to account for level effects in efficiency, because we calculated the FDH score for each unit with reference only to the units of the same discipline. Since FDH scores are "normalised" (i.e. one or above) discipline specific level effects should largely be absent.

In the following, we adopt the strategy of offering explanations for the estimation results explicitly only for those that do not follow directly from the discussion on NPM in Section 3.4. After each passage we summarise the main conclusions in catch phrases.

We start with some very general observations. It may indeed be ascertained that the influence of the different NPM governance mechanisms differs as the output bundle changes. Some variables (especially COUNCIL, EVAL, and GOAL) are significant only for some output bundles. Some variables (especially PERSONNEL, PRESIDENTS, and ACCOUNT) are significant over (almost) all output bundles, while the variable DEANS is not significant in any. Interesting with the last observation is that the presidents and chancellors in fact have a profoundly positive impact on research efficiency, while we cannot detect any such effect for the deans. Two explanations seem reasonable. First, the deans are elected by those who they ought to govern and after their election period ends, they return to the subgroup of people who are governed. This may lead to situations where the deans remain rather inactive by setting weak incentive schemes (Wigger and Dehm, 2006). Closely related is the more sociological argument that the deans are socialised within the science system and therefore, by ethos, will not push the subordinate chair holders too hard (de Boer et al., 2006). The presidents, on the contrary, may be far enough away from the units at the basis to take unpopular actions.

> *Conclusion 1: most NPM variables tested have a profound impact on research efficiency. Some of them, especially the existence of rigid personnel quotas, the influence of presidents and chancellors, and the existence of an accounting model have an impact under almost all output definitions.*

After a more detailed look at the results, we can state that the variables COUNCIL, EVAL, GOALS, PERSONNEL, and PRESIDENTS, when significant, have the sign predicted by NPM, while the introduction of an accounting tool (ACCOUNT) curiously has a negative impact on research efficiency. In fact, the latter result seems counterintuitive. However, three explanations may seem reasonable. First, the additional effort of maintaining an accounting model simply outweighs the positive effect from more reliable information and feedback on management decisions, especially if the research unit is small. Second, many leaders of research units may not be familiar with accounting models and therefore tend to ignore the data from such models. However, if the second explanation is true then, over time, the usefulness of accounting data may grow as the chair holders get accustomed with it. Third, accounting systems cannot simply be carried over to the needs of research units. This is true especially because the cost and activity accounting has to be

[6] With ordinary least squares (OLS) regression it is common to present the R^2 measuring the fraction of variance explained. However, the R^2 relies on a variance decomposition formula that only works with OLS. In a non-linear regression like the employed truncated normal model R^2 may well take values below zero. Therefore this measure is certainly of little use to assess overall explaining power of the model. To get an intuition for how good the model is, the same model was run by OLS. R^2 actually was rather low, and never exceeded 20%. Although OLS regression is inappropriate in this case, this still indicates what could be already expected; efficiency in research depends on a lot of other factors besides the governance model, such as personal qualification, which we simply cannot measure. Inasmuch the governance model is exogenous, i.e. no research group has considerable influence on it, the model still is useful: it still estimates the effects of NPM correctly, although it will perform less well in predicting the efficiency level of research group only from its governance scheme. In any case, we do not want to use the model for any kind of prediction but only for the assessment of the effects of NPM.

Table 2
Influence of NPM variables on research efficiency—truncated normal regression model.

Dependent variable: input-oriented FDH score				
	Balanced	Transfer-oriented	Teaching-oriented	Publication-oriented
CONST	0.8984**	1.9881**	1.4934**	1.1833***
Increasing operative flexibility				
PERSONNEL	−0.7041***	−0.2427	−0.4385***	−0.5024***
Increasing accountability				
DEANS	0.0738	−0.0589	−0.0625	−0.0192
PRESIDENTS	−0.2318***	−0.1451*	−0.0781	−0.0917*
GOAL	0.1151	−0.4793***	−0.1790	0.0092
Resource control and feedback				
ACCOUNT	0.3557***	0.3330***	0.2208*	0.2768***
Increasing strategic capabilities				
COUNCIL	−0.1730	−0.4352***	−0.2473**	−0.0804
EVAL	−0.1451	−0.1156	−0.0110	−0.3461***
n	243	243	243	266

*** Significant at 1% level.
** Significant at 5% level.
* Significant at 10% level.

reduced to a pure cost accounting, since the results from research activities are either hard to price in the absence of a market or are completely intangible (for a discussion see Ambrosy et al., 1997). It might be true that the frictional losses from an adoption of these models originally developed for companies are too high to make them a useful tool. In any case, we must be careful in interpreting this result. As seen in Table 1, some of the research units in the sample are very large. 6 units were larger than 35 scientists (excluding doctoral students) and many of these had an accounting system. We are quite sure that it would be very unwise for the units to stop controlling resources for obvious reasons. The estimation results are likely to come about because the sample is dominated by small units, where the need for bookkeeping might be limited.

Conclusion 2: except for the introduction of accounting models, which affects efficiency negatively under any output definition, all other NPM variables contribute positively to research efficiency. Strong presidents and chancellors as well no- existence of personnel quotas have a positive impact under three out of four output definitions.

Turning to the variables which are significant only under some output definitions (COUNCIL, EVAL, GOAL), some interesting patterns emerge. First, evaluations affect efficiency only for the publication-oriented scheme. Once again, some ad hoc explanations may be found. On the one hand, it may be possible that evaluations set a special focus on the assessment of research activities, i.e. if they focus on, say teaching, they would affect teaching positively. On the other hand, evaluations tend to have a long-term horizon by creating incentives for setting out a long-term agenda. To the extent, that publication-related activities cannot be changed from 1 day to another, this might simply make them a very appropriate tool to foster basic research. Second, goal agreements are significant only for transfer-dominated activities. This is pretty obvious because goal agreements tend not to be related to publication activities, but instead are tailored towards more routine tasks, such as cooperation with companies. However, the expectation was that this variable would be significant for teaching as well. Third, the existence of research councils has a significant impact on transfer and graduate teaching. This, on the contrary, meets the expectations completely, because major players in the councils are state representatives. Research councils are a modern channel for state authorities to exert their former direct influence. In any case, it is known from the German policy debate that the responsible authorities have a high preference both for education, and therefore graduate teaching, as well as short- to mid-term economic goals, and in following that, for knowledge transfer to companies (Hassink, 1996, compare also Schimank, 1988). The argument implied then is that the estimation results simply reflect the preferences of the research councils.

Conclusion 3: publication-related activities are made more efficient by regular evaluations of the research units. Efficiency in technology transfer tends to be increased both by goal agreements and the existence of research councils, while efficiency in teaching activities is increased by the existence of research councils.

Apart from the question, whether a certain governance mechanism exerts a statistically significant influence, the magnitudes of the effects as well are important to know. That is to say, we need to know, if the effects that show up in Table 2 are not only significant but also large. Unfortunately, from Table 2 alone this is hard to ascertain, since the truncated-regression coefficients cannot be interpreted as marginal effects[7]. Anyhow, there are formulae (not presented here) to calculate them. A further problem is that the marginal effects might not be too informative, since the independent variables can have totally different units. One way to deal with that would be the use of standardised beta coefficients. However, since we are in a lucky situation where all independent variables are bounded, either to zero and one (dummy variables) or from one to five (Likert scale variables), we can calculate maximum marginal efficiency effects for a variable based on marginal effects. A maximum marginal effect is similarly defined as a usual marginal effect. However, it does not give the effect on the dependent variable, if the explanatory is changed by a marginal unit but it gives the effect of variable that is changed from its lowest possible to the largest possible value. For binary (dummy) variables this is simply a switch from 0 (mechanism absent) to 1 (mechanism present). For the Likert scale variable this is a switch from 1 (lowest level) to 5 (highest level). These maximum effects are given in Table 3. In easy words, if a certain unit has the lowest possible value for a certain variable,

[7] A marginal effect of an independent variable determines by how much the dependent variable changes, when the respective independent is changed by one marginal unit. When the independent variable is discontinuous like those in Table 2, then the marginal effect rather is a finite difference effect. For example, the marginal effect of the introduction of a research council is the estimated difference in the efficiency measure when the variable COUNCIL switches from zero to one not changing any of the other independent variables.

Table 3
Maximum marginal effects of the NPM variables.

	Balanced	Transfer-oriented	Teaching-oriented	Publication-oriented
Increasing operative flexibility				
PERSONNEL	−0.2086		−0.1469	−0.1618
Increasing accountability				
DEANS				
PRESIDENTS	−0.2296	−0.1448		−0.0214
GOAL		−0.1696		
Resource control and feedback				
ACCOUNT	0.0989	0.0964	0.0659	0.0784
Increasing strategic capabilities				
COUNCIL		−0.1358	−0.0692	
EVAL				−0.1206
Mean estimated inefficiency	0.1575	0.2936	0.2485	0.1908

then the maximum efficiency effect is the expected increase in efficiency, if this variable is set to its maximum value (e.g. by replacing a very weak president by an extremely powerful).

We followed the strategy of giving the effects only, if the underlying coefficients are significant (see Table 2). According to this table, we find large, medium and small effects. Among the large effects are rigid personnel quota (whose abolishment *decreases* inefficiency by 0.2086 in the case of the balanced scheme) and strong presidents (where maximum possible inefficiency reduction is 0.2296 under the balanced scheme). On the other hand, under the transfer-oriented scheme the effect seems to be smaller with only 0.1448. Other medium sized effects include PERSONNEL (teaching- and publication-oriented scheme), COUNCIL (teaching-oriented scheme), EVAL (publication-oriented scheme), and GOAL (transfer-oriented scheme). The efficiency losses induced by the introduction of accounting tools are always comparably small, such as the effect of COUNCIL under the teaching-oriented scheme.

Being able to distinguish between *relatively* small and large effects is certainly not enough. We also need to answer the question, how large the effects are compared to total inefficiency, i.e. can NPM considerably reduce inefficiency or is it just a drop in the bucket. And indeed, when looking at mean total inefficiency, which is the mean deviation from the absolute efficiency score of 1, we see that this ranges from 0.1575 to 0.2936. So the effects are large. For example suppose a certain research group is averagely efficient under the teaching-oriented scheme, i.e. has an efficiency score of 1.2485, and has not yet introduced any of the NPM mechanisms, then it could decide to abolish rigid personnel quota and introduce a research council. This would lead to an expected decrease of inefficiency of 0.2161 (0.1469 + 0.0692). So its expected new efficiency level would be 1.0357, which is almost absolutely efficient. Therefore, these two instruments would have reduced inefficiency by almost 86% (0.2161/0.2485). Indeed, if this unit had already introduced an accounting system, then it could actually jump from an expected level of 1.0357 onto the efficient frontier by abolishing it.

Conclusion 4: with respect to mean inefficiency the effects of the NPM mechanisms are very large, yielding the insight, that universities may indeed increase efficiency of their research groups considerably by choosing their governance model wisely. Some variables such as abolishment personnel quota and power of presidents show an extra-ordinarily large effect. The negative effect of accounting schemes is, although significant, not very large.

4. Are there management implications?

The analysis of Section 3.5 has served to underpin that the latest NPM reforms have exerted a positive influence on the usage of resources in the public research sector. A question that directly comes to mind is whether these results may be used to guide the practical introduction of NPM instruments. For example, it is tantalising to conclude from Table 2 that it would be wise to strengthen the presidents, abolish personnel quota (as well as accounting tools) and introduce regular evaluations, if the university has a publication-oriented research mission and would like to increase efficiency. In fact, this might be misleading, since the NPM variables from above, covering a multitude of aspects of NPM, are certainly very rough. For example, looking at the variable of strong presidents (having a positive influence on efficiency in most output schemes), we did not really dig deep enough to determine what a "strong president" actually does. Is he active in representing the university in front of external stakeholders? Does he defend the university against influences from state authorities? Or does he do the opposite by pushing the subunits into a direction desired by the state authorities. Finally, if we claim that influential presidents are efficiency increasing, this will certainly only hold true, if they use their power wisely. Thus any conclusion that could potentially be drawn should also be made contingent on the specific situation of a university. Making management recommendations would therefore require understanding what is behind the rather general variables from Section 3.

Recognising these limitations, we believe that we cannot go far beyond the conclusions of the previous section. However, some notable comments can still be made. But let us first have a look on how many of the research units actually have governance models that – from the regression results of Table 2 and 3 – seem most favourable in the face of differing university missions.

Disregarding the introduction of accounting systems, which exerts a negative influence on efficiency, we saw that it is possible to classify the NPM instruments according to their objective, i.e. increasing strategic capabilities, increasing accountability, and increasing flexibility. The NPM instruments recommended for certain output-profiles can be read off Table 2. However, for an easy overview they are summarised in Table 4, e.g. the balanced scheme requires strong and active presidents and the abolishment of personnel quotas. The publication-scheme additionally requires regular evaluations. So to speak, the NPM style optimal for a balanced scheme is weaker than that recommended for the publication-oriented scheme.

Starting with a bit of descriptive statistics, a few observations are worth noting.[8] First, the share of research groups without any

[8] A research group was classified as having a certain governance type, when the discussed instruments were all introduced. In the case of dummy variables, this simply occurred when the variable took a value of 1. For the Likert-scale variable "power of presidents" this was taken for granted when the observed value was above average.

Table 4
NPM styles and empirical importance.

Type of instrument	Hierarchical				Non-hierarchical	% of the sample
Object of governance	Strategy		Accountability		Flexibility	
NPM style	Research councils	Evaluations	Strong presidents	Goal agreements	No personnel quotas	
Balanced			X		X	11.11
Transfer-oriented	X		X	X		14.70
Teaching-oriented	X				X	13.98
Publication-oriented		X	X		X	4.66
Balanced &transfer	X		X	X	X	1.79
Balanced & teaching	X		X		X	8.60
Balanced & publications		X	X		X	4.66
Transfer & teaching	X		X	X	X	1.79
Transfer & publications	X	X	X	X	X	1.43
Teaching and publications	X	X	X		X	3.58
All styles used						1.43
At least one style used						26.88
No NPM instrument used						6.81

NPM instruments is with 6.81% rather low, which means that almost all universities have made at least some effort to reorganise their governance model. However, the share of units working with all instruments being favourable for a particular output-scheme is also rather low. Only 11.11% had introduced all instruments associated with increased efficiency in the case of the balanced scheme. 14.70% introduced a governance style that benefits a transfer-orientation. This share is similar to that of teaching-orientation (13.98%), while it is a lot lower for publication-orientation with only 4.66%. In total 26.88% of the units followed at least one of the governance models associated with greater efficiency. Since this share is less than the summation of the shares of the NPM styles, it is obvious that many groups used combinations of these styles. For example 8.60% have introduced all instruments promoting the balanced scheme but have additionally also introduced all instruments promoting the teaching orientation.

As argued above, making further management recommendations might easily run the risk of yielding false conclusions. Thus, we refrain from giving an easy recommendation such as: "If the university has a publication-oriented mission, then introduce evaluations, abolish personnel quota, and increase the influence of the presidents."[9]

Not giving such a patent remedy recommendation has three reasons. First, it is unknown what is behind the variables. Second, personnel management is never something mechanical but should be tailored towards the specific needs, interests and capabilities of the people being steered. Third, universities usually have missions that entail more than one objective (e.g. publications).

Despite these objections, that does not mean that the results are of no use for practical decision making at all, since they indicate that there is something to gain by the governance model. How this knowledge can be used in a more appropriate way is exemplified by the case of the German Technical Universities.

The German Technical Universities, being founded mostly in middle of the 19th century, had a very transfer-oriented profile at that time. And, although they preserved this profile, many of them today are among Germany's leading research universities. Thus, they also have publication-oriented mission as well. Adding to the arguments above, the Technical Universities in Germany represent prototypical cases where it is impossible to define a clear-cut mission consisting of just one objective. In essence, such a university should seek measures that foster both the activities of transfer and genuine research.

[9] These are the three variables benefiting the publication-oriented output scheme.

Since genuine research and linked to it publishing activities require individuality and freedom, setting a suitable governance model requires operative flexibility for the research groups (for example the abolishment of personnel quota). Additionally, since constantly high performance requires setting a long-term research group strategy, evaluation could help research units to develop sustainable research agendas. To account for the dimension of transfer this objective could be supported by installing research councils with a high share of members from industry, who can help to make the needs of enterprises more explicit and can also establish contacts.

In this context, the contribution of the results of Section 3 is that these measures actually are promising. However, they should not be misused to develop patent remedies for constructing governance models. Additionally, they show that introducing NPM steering mechanisms are not ends in themselves. Instead, in the light of the mission of the university, it should clearly be stated how they may contribute to it (see the example above). This recommendation clearly is in line with Chandler (1962) famous postulation "Structure follows Strategy", where the structure is the NPM style and strategy is set equal to the mission.

5. Conclusion

It was demonstrated that many NPM instruments have a positive influence on research efficiency. In any case, this depends on the definition of what research activities actually comprise. Evaluations are a reasonable mechanism to enhance publishing activities. Goal agreements and the existence of research councils push the research units in the direction of increased transfer and teaching efficiency. High competencies of the chancellors and presidents as well as the non-existence of strict personnel quotas contribute positively almost everywhere. We conclude that NPM may exert considerable positive effects on university research if not employed blindly. We have also provided hints on how a university may choose its particular governance model with respect to its mission. Summarising, the NPM reforms have proved useful in guaranteeing a more effective spending of governmental resources.

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