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EFFICIENCY AND UNIVERSITY SIZE: DISCIPLINE-WISE EVIDENCE FROM EUROPEAN UNIVERSITIES

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14.1 Introduction

It is essential to university strategy that decisions about the offering profile, expelled as a mix of outputs, depend on constraints on the inputs. Universities deal with how to make the best use of their existing resources, and procure future resources, in order to make their competitive position sustainable in the long run. Strategic management must build the best possible relation between resources and offering, or inputs and outputs. One relevant question, in this perspective, is whether the unit is making the best use of existing resources, or whether *technical* efficiency is in place.

Clearly, efficiency is not the only relevant strategic question, but it is one of the most important. The lack of any link between inputs and outputs may be fatal for any strategy, whatever ambitious it may be. Efficiency as an important topic in the broader research agenda of university strategy is discussed in detail in Bonaccorsi and Daraio (2007). Here we address the question of technical efficiency with respect to university's size. The crucial concept in this analysis is conditional efficiency and the ratio of size-conditional to unconditional efficiency measures. In particular we take use of robust order-m efficiency scores presented in Cazals, Florens and Simar (2002) and generalized in Daraio and Simar (2005a,b).

To get any reasonable results concerning efficiency and unit size requires relatively large and homogeneous data sets. In European countries the number of universities in a single country usually does not allow such an analysis. Also in the countries with hundreds of universities like UK, Germany and France the homogeneity requirement is usually not met. Generally, the homogeneity requirement is best met if research fields, instead of universities as such are compared. In this article we make for the first time a use of research field data in a set of European countries from Aquameth data bank. The data is created in a Prime network of excellence (www.prime-noe.org) project by researchers from more than ten European countries.

The paper unfolds as follows. In section 2 we give a detailed reasoning for methodological choices done, by discussing the university production as a specific type of multi output decision problem. Section 3 introduces the Aquameth databank and the sample to be used in the analysis. Our efficiency model covers four research fields in the universities of four European countries, namely Finland, Italy, Norway and Switzerland. Section 4 present the results and discusses the further possibilities of micro level international university data banks.

14.2 Methodology to measure university production

In addressing this important but also risky comparative analysis among some of the Aquameth countries we have done a series of theoretical and methodological choices in the hope to overcome some of the most difficult limitations of the existing literature.

First of all, we adopt the choice of *research field within a university* as the appropriate level of analysis, taking into account the complex embeddedness of the higher education system it operates in. This is part of a more general effort, undertaken under the PRIME network, to establish the microdata level as the appropriate one for analysis and policy. By using the research fields we go a bit further than Bonaccorsi et al. (2007) that use university institution level data. It must be noted that most of economics of research and innovation and of related policy making routinely uses national level aggregate data, in the tradition of Frascati and Oslo Manual. While these data are of large value for analysis and decision-making, they mask internal differences in national systems and loose important specificities.

Second, we need an approach that directly addresses the issue of *complementarities*. The theory of complementarity is one of the least developed in economics, and many standard problems are addressed in terms of simple marginal rates of substitution, ignoring nonlinearities and external influences. Some of the most intriguing problems in these fields, however, require exactly an estimation of complementarity or substitution effects. Consider as an example, the complex trade-offs between research and teaching, between undergraduate and postgraduate teaching, between publication and patenting, between research and third mission activities: here we need to estimate substitution versus complementarity effects that may *not* be stable across all the relevant distribution of variables.

Third, higher education institutions are not only multi-input, multi-output production units, but also transform resources in nonlinear ways. Techniques for analysis must be flexible enough to represent the complexity of production processes. We propose that an appropriate research strategy must fulfill the requirement for multidimensional mapping. Techniques must be able to represent the interaction between resources and outcomes, rather than giving monodimensional pictures.

In the current literature these three requirements are never satisfied jointly. The institutional literature on national systems of higher education or research sometimes gives a qualitative and narrative account of complex trade-offs and nonlinearities in university production, but does not use data at the microlevel and on a large scale to support its claims[1]. On the other hand, the econometric literature deals with individual observations but rarely uses large cross-country datasets. Moreover it tends to adopt highly restrictive assumptions.

The econometrics of higher education emerged from the development of human capital theory and the efforts to estimate rates of return to education in the 1960s and 1970s.[2] Within this literature, broadly speaking, two different classes of quantitative methods have been adopted: parametric methods based on the notion of production function, and nonparametric methods adopting a more general frontier approach (see Bonaccorsi and Daraio, 2004 for an overview). All these methods have advantages and limitations that are discussed in Chapter 6 of this volume.

It is interesting to note that the recent developments of the two fields in the efficiency literature (parametric and nonparametric one) converge towards a flexible approach in which the limitations of both approaches are defeated using contributions from the other front (Daraio and Simar, 2007). For instance, statistical inference is now feasible in the nonparametric approach and parametric approximations

1 This is due very often to the lack and limitations of available data at the micro level. The Aquameth Project tried to fill this blank.
2 For a review of the literature on the econometrics of higher education, developed in the last 40 years, see Ehrenberg (2004) which identifies the following strands: (a) rates of return to higher education, (b) academic labor market, (c) institutional behavior and (d) higher education as an industry.

of robust nonparametric frontiers are available, using also flexible functional specifications.

Recently introduced robust nonparametric techniques such as order-m frontiers (Cazals, Florens and Simar, 2002; Daraio and Simar, 2005a, b) face the problems of *curse of dimensionality* (loss of accuracy with large number of variables) and outliers. The main idea behind these techniques is that the estimation of the production frontier is not made by enveloping all the observed points, but by sampling repeatedly on observed points (m times with samples of size n) and building averages of samples, up to the point where the resulting hypothetical frontier has the desired precision. In this way the effect of outliers could be greatly reduced, even with sample of moderate size (robustness). In this paper we will make systematic use of order-m frontiers and other probabilistic measures[3] because we believe they are the most flexible tools available for the analysis of the higher education and research system at the microlevel. Since we have to deal with complex trade-offs, complementarity effects, strong nonlinearities, and we know that many underlying distributions at individual level are highly skewed, we do not feel confident with conventional econometrics.

Conditional efficiency

In science and education, external factors may be a cause of heterogeneity and may considerably affect the performance of universities. Several efficiency studies, have tried to face this problem by developing and applying one, two or multiple-stage approaches to take into account what they define as *socio-economic differences* (see e.g. Ruggiero, 2004). The basic idea has been to relate efficiency measures to some external or environmental factors which might influence the production process but which are not under the control of the managers.

3 For a systematic and comprehensive treatment of recent developments in nonparametric and robust efficiency analysis see Daraio and Simar (2007).

Unfortunately, both one stage and multiple stage approaches are flawed by restrictive prior assumptions and/or on the role of these external factors on the analysed process. On the one hand, as discussed and demonstrated by Simar and Wilson (2007), the multiple-stage approaches suffer from methodological problems related to the complicated and unknown autocorrelations between the estimated efficiency scores used as dependent variable in the second stage regression, but also to the inherent bias of the first stage efficiency estimates. On the other hand, in the one stage approach first proposed in the literature, one has to assume the effect of the external factors on the production process, i.e. the analyst should know in advance if the external factors affect positively or negatively the comprehensive performance. Of course, these problems and assumptions are very strong. Daraio and Simar (2005a,b), generalizing the approach of Cazals, Florens and Simar (2002), propose a full nonparametric methodology to explain efficiency differentials by external environmental factors that overcomes most limitations of previous approaches.

The robust nonparametric approach we apply in this chapter is based on order-m efficiency scores and other probabilistic measures which add some new advantages to the traditional nonparametric approach (DEA/FDH based): these indicators are more robust to outliers and noise in the data; they avoid the *curse* of dimensionality, typical of nonparametric estimators, meaning the necessity of increasing the number of observations when the dimension of the input-output space increases to achieve the same level of statistical precision; the order-m indicators make it possible to compare samples with different size, avoiding the *sample size bias*.

Developing further this approach, Daraio and Simar (2007) introduce a full range of robust and *conditional* measures of efficiency, i.e., efficiency scores affected by external factors. They also propose a simple methodology to explain efficiency differentials by these *external factors Z*. The procedure is based on the comparison of the *conditional* efficiency measure with the *unconditional* one. The conditional measure adjusts efficiency upwards if external factors are unfavourable. Therefore, the ratios of conditional/ unconditional robust order-m efficiency scores (called Q_m^z) are useful to investigate the effects of *Z* on performance: if $Q_m^z = 1$, then the conditional and unconditional efficiency measures are equal: this means that *Z* does not affect the performance of the analysed unit. In this study, the efficiency models used to calculate the order –m efficiency scores are all output oriented. Thus, we assume that the primary target is to maximize outputs with given inputs. Efficiency score in each model indicates how much larger the unit's outputs could be when compared to peer universities. Thus, the lower conditional efficiency score compared to unconditional, i.e. $Q_m^z < 1$, indicates improved efficiency due to conditioning as well as present disadvantages of external factors.

When *Z* is univariate, the scatterplot of these ratios against *Z* and its smoothed nonparametric regression line is also very helpful. By looking at this picture, the analyst has an immediate view on the global effect of external factors on the performance: an *increasing* line indicates a positive influence of the factor, a *decreasing* line points to a negative effect and a *straight* line reveals no influence of the factor on the performance. This kind of picture is able to point out the peculiar behaviour of some institutions and shed lights on the heterogeneity on the analyzed sample.

14.3 The Aquameth dataset and the efficiency model

Aquameth is an acronym for Advanced Quantitative Methods for the Evaluation of the Performance of Public Sector Research. It is a subproject of Prime network of excellence as a part of 6th EU Framework Programme. Currently Aquameth runs on its 3rd stage called Aquameth Consolidation with main emphasis on consolidation of the dataset and methodology.

One of the basic achievements of the Aquameth has been the integrated university and research field level dataset on project participating countries. It refers to resource usage and products obtained both in teaching and research at universities as well as other several financial measures. The coverage of the dataset is currently 10 countries: Finland, German, Hungary, Italy, The Netherlands, Norway, Portugal, Spain, Switzerland and UK and altogether 394 universities. Also France has been active in the project, but has not yet been able to contribute to the dataset. The project is also actively looking for new spatial extensions to the dataset. Dataset coverage is illustrated in Table 1.

Table 1. Aquameth dataset coverage

Country	Number of Universities	Number of Variables	Time period
Finland	20	55	1994–2006
Germany	72	12	1998–2003
Hungary	16	5	1997–2004
Italy	79	60	1994–2006
Netherlands	13	18	1994–2004
Norway	4	45	1995–2003
Portugal	14	36	1994–2003
Spain	48	62	1994–2002
Switzerland	12	53	1994–2002
United Kingdom	116	60	1994–2005
Total	394	82	1994–2006

The basic observational unit in the data set is a university, where the data comes from. For the key variables like the number of enrolled students, degrees awarded and academic staff these figures are also available for the five aggregate research fields: Engineering and Technology, Medical Sciences, Natural Sciences, Social Sciences and Humanities and miscellaneous. The aggregation rules are necessarily rough, for example agricultural sciences are aggregated to engineering, human and social sciences cover all the behavioural sciences as well as history and business studies. Miscellaneous cover unspecified data. The current version of the dataset covers observations from 40 different properties of the university, accounting observations form different research fields yields 82 independent variables.

The categories of the dataset variables are presented in the Table 2. The key areas are general information about the university's type, location and age, revenues from public sector, private agents and tuition, expenditures on personnel, teaching and research, the amount of personnel, granted degrees and publications in refereed journals.

Table 2. *Aquameth dataset categories*

AREA	CATEGORIES	AREA	CATEGORIES
General information	Year of foundation City, province, region (NUTS) Number and type of faculties/schools/disciplines covered Governance (public, private) Type (university, technical college) Other relevant historical information	*Personnel*	Total staff (FTE or headcount) Professors Other academic staff Technical and administrative staff
Revenues	Total revenues of the university General budget of the university (in federal countries divided between national and regional appropriations) Tuition and Fees Grants and contracts, if possible divided between government, international, private and private non-profit Other expenditures	*Education production*	Number of undergraduate students Number of undergraduate degrees Number of PhD students Number of PhD degrees
Expenditures	Total expenditures (excluding investments and capital costs) Personnel expenditures, if possible divided between personnel categories Other expenditures	*Research production*	ISI publications

The comparability issue in this kind of international dataset is necessarily crucial. It is discussed extensively in Bonaccorsi, Daraio and Lepori (2007). Bonaccorsi, Daraio and Simar (2007) has ended up using universities' offering profiles, i.e. the amount of outputs, constrained by their input usage to study how universities try to keep their competitive position sustainable in the long run. They used university level data and used the total number of academic staff and total number of technical and administrative staff as inputs to produce graduate degrees (masters or bachelor) and articles in refereed journals. Technically the ratios in which professors, lecturers, researchers and other staff is needed depends on the research fields presented in universities. Bonaccorsi, Daraio and Simar (ibid.) solved this problem by using the sub sample of what they called generalist universities, covering universities that presented several strong research fields. In this paper we adopt another strategy; we estimate the conditional and unconditional efficiencies from the sub sets of research fields. More detailed disaggregation requires some changes in production variables used.

Outputs of education may be measured quantitatively as the number of degrees, study points or any other measure of contacts with students. Qualitative measures range from achievements levels to post education employment. Research output is usually measured as publications, but frequently also as research income. Our selection of output variables is based on the currently reasonable country and research field wise coverage of the dataset. Therefore, we have to content with an explorative model, where teaching output is measured as the number of undergraduate degrees. For the research output we use the number of ISI publications in refereed journals. Especially the availability of ISI data on research field level limits the analysis to the year 2002. To reduce the role of annual variation, publication figures are averages over 2000 to 2002.

As an input for conjoint production of teaching and research, we could basically use expenditures or any set of personnel and enrolment. Even if expenditure data is collected in dataset, due to different institutional and managerial structures of universities, it is hardly comparable. The current version of dataset gives the numbers of professors, other academic and the total number of staff for each research field. As the definition of a professor varies over countries, we assume that the total number of academic personnel in the field as an input variable approximates best the teaching and research potential of the unit.

We are specifically interested in assessing the impact of the unit's size on efficiency. When the basic observation unit is a research field, the size of the unit may be associated with the absolute size of the unit itself or to the size of the academic environment as whole, i.e. the parent university. We measure the former with the number of enrolled students in the field and the latter with the size of academic staff in the parent university. Both measures capture possible gains from interdisciplinary environment, but the size of parent university covers also infrastructure and the competition of resources between the research fields. The absolute size of a unit captures possible gains from the critical mass within a research field.

14.4 Efficiency and the unit size by research fields

In this section we estimate the models and measures presented above using the Aquameth data set. In this very first experiment of using international data at research field level the coverage is limited to four countries, namely Finland, Italy, Norway and Switzerland. The observations are from year 2002. We will use the data from four disciplines, as reported in Table 3.

Table 3. The number of universities in the sample

	Number of universities				
	Finland	**Italy**	**Norway**	**Switzerland**	**Total**
Engineering and Technology	5	49	2	5	61
Medical sciences	5	38	4	6	53
Natural Sciences	8	41	4	9	62
Social sciences and Humanities	18	53	4	10	85

Even if the problems in comparability do not allow direct efficiency comparisons using the conjoint model, we conduct partial efficiency analysis to illustrate the country wise differences. For each research field in turn, in the first figure we have a scatter plot of partial efficiency ratios, i.e. simple output to input ratios, to look how much the efficiency patterns differ between the countries. Thus, we see how the number of graduates relative to academic staff is associated with level of publication activity. The input variable here, the number of academic staff in the field, is modified for Italy to cover also all the contracted academic employees.

A great advance of analysing conditional/unconditional efficiency ratios, Q_m^z, is that they reduce comparability problem in this kind of international data. The strategy is to calculate robust order-m efficiency scores from two separate models; the one that does not take into account the size factor (unconditional model) and the one taking into account the size of the units (conditional model). Otherwise the models are identical, thus comparing the individual efficiency scores reveals the impact of size and the result is not sensitive to measured level of efficiency, which typically varies a lot due to problems in comparability. Also, the robustness of the measure ensures that single outliers do not dominate results.

In our conjoint model the efficiency figures cover both teaching and research activities simultaneously. For each research field in turn, figures report on the vertical axe the ratios conditional /unconditional scores (Q_m^z) and draws a smoothed nonparametric regression line[4] that indicates local changes in efficiency patterns respect to the size factor (horizontal axe). In the panel on the left, the size is measured

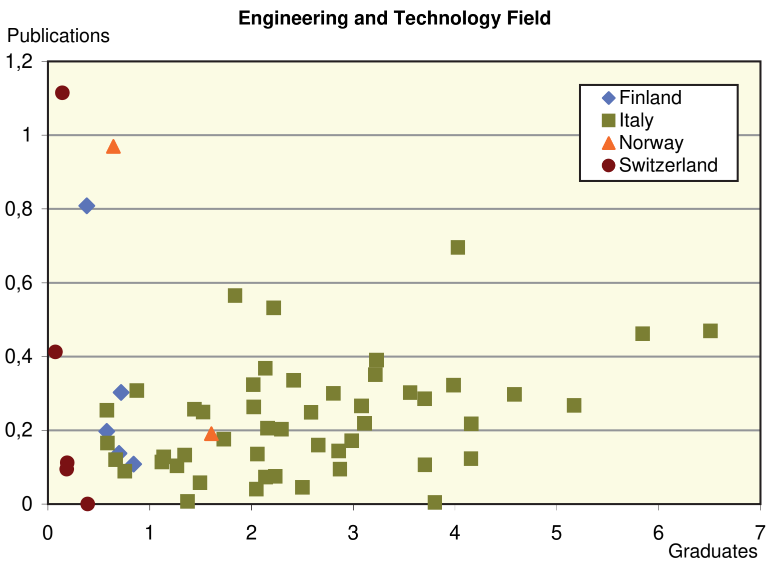
4 Non-parametric regression line is estimated using Nadaraya-Watson kernel estimator, see e.g. Ullah (2001).

by total academic staff in the university and in the panel on the right by the number of enrolled students in the field.

Engineering and Technology Field

In Figure 1 we have a scatter plot of the two output measures used. The ratio of graduate students to academic staff is plotted against the number of ISI publications per head this staff has published. The country-wise differences in the graduation data are clear; all the Swiss universities are located left of Finnish ones, indicating lower graduation-staff ratio. The most of the Italian universities has higher graduate-staff ratio than in Finland, such that the ratio of the most productive universities is 7-fold to Finnish ones.

Figure 1. *The ratios of graduated students (horizontal axis) and publications (vertical axis) to academic staff in Engineering and Technology domain*

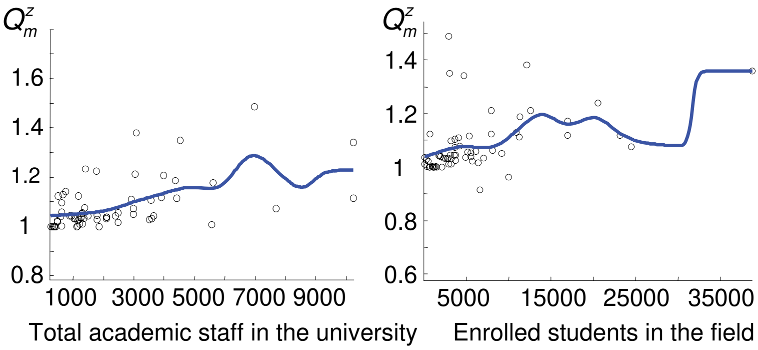


Using ISI publications is probably not the best choice for a research activity indicator in Engineering and Technology field. At least the evidence from Finland shows that in engineering schools the main channels for publications are the international conference proceedings and comparable non-refereed international collections (Chapter 13 in this volume). However, in our sample countries the mean publication rate is 0.25 ISI articles annually. The data from countries differ quite little, except for one unit from each Finland, Norway and Switzerland, having publication rates close to one.

The range of graduation figures for Finland, Norway and Switzerland appears far too narrow to see if teaching and research have any correlation. For the whole sample, due to country wise differences and the data range of Italian universities the regression line in Figure 1 would have clearly positive sign. At least we can draw the conclusion that high number of graduates per academic worker does not prevent success in international refereed publication forums.

To find how the different size measures have impact on universities efficiency, we run the conjoint efficiency model for teaching and research having the number of academic staff in the field as an input. As we already saw from the first figure the graduation/staff ratio varies a lot between countries as well as within Italy. Thus in the panel left, size is measured by the total academic staff of the whole university and in the panel right by the number of enrolled students in the field.

Figure 2. *Impact of size on the conjoint teaching and research efficiency in Engineering and Technology domain. Panel left, total academic staff of the university. Panel right, the number of enrolled students in the field*



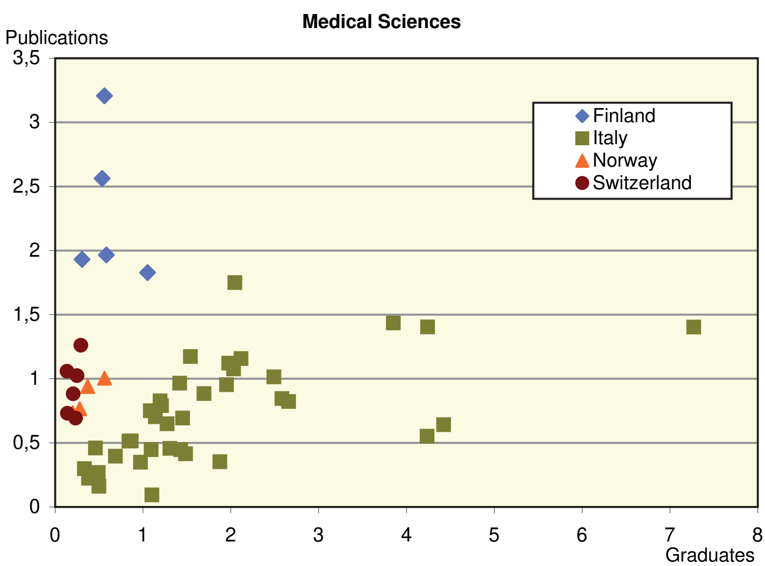
The conditional efficiency score always exceeds the unconditional one if the university size is considered as a size factor (left panel). Also the smooth nonparametric regression line has a positive slope over the densest data region. In other words, the university size seems to have generally a positive impact on overall efficiency in teaching and research. Also, the larger the units get, the more they gain on the size in Engineering and Technology. Note, that this does not imply that larger units are more efficient, but they appear to have more efficiency gains than smaller units. The evidence within the data set is clear up to the universities with faculty less than 6 000; for faculties higher than 6 000 employees the pattern is less evident as there are a small number of universities in this region.

The result is generally the same if the size is measured by enrolled students, even if now two schools, Norwegian School of Science and Technology and Tampere University of Technology, seem to under perform with respect to their size.

Medical science

Nonparametric regression estimates based on the Finnish KOTA-data bank suggest that 95 % of the total research effort in Medical Sciences is devoted to refereed international articles (Chapter 13 in this volume). However, in Figure 3 the number of publications per academic employee in the sample countries differs remarkably. Finnish schools reach higher publication rate than any other medical school in the sample. An academic employee publishes about one ISI paper in Switzerland, and in Norway usually a bit less than one paper. In Italy, the variation in publication activity is high. In 12 schools of 38 an academic employee publishes a paper no more that every other year on average, while in 9 schools publication ratio exceeds unity, and roughly speaking at least four universities reach the same range, [1.4, 2], than the three Finnish universities.

Figure 3. *The ratios of graduated students (horizontal axis) and publications (vertical axis) to academic staff in Medical Science domain*

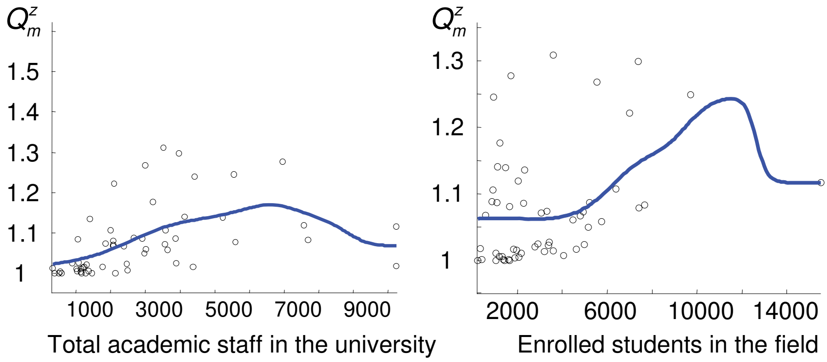


In the number of graduates per academic employee, the variation in Italy is again the highest. In other countries the sample is more homogeneous, or the actual staffing is more regulated. However in 10 Italian schools graduation ratio is within the same range as their international sample peers.

The number of graduate degrees and published papers per an employee seems to have a positive correlation. Finnish, Norwegian and Swiss schools in medical science are able to publish more frequently than their Italian counterparts, but also Italian schools increase their publication activity as the number of graduates increase. This pattern is strongest in Medical and Natural sciences. In these fields research in undergraduate levels more easily results in publications also in international refereed level.

For the Medical Science domain we observe an interesting inverted U-shaped pattern in efficiency with respect to the size (Figure 4). The effect of size on conjoint production of research and teaching activities is positive up to a total faculty of 6 500 academic employees and then the effect turns to a decreasing trend in the region where there are only 5 big universities. The role of Medical Sciences in the largest 5 parent universities varies a lot. In Roma La Sapienza and University of Zurich Medical Sciences are clearly relatively large units, with 15 % (Roma) and 27 % (Zurich) share of the total university staff. Helsinki and Napoli Medical Sciences cover about 7 % of the total staff, whilst in the Swiss Federal Institute of Technology Zurich, ETZH, medical department is relatively small, just 156 academic faculty members covering only 1.5 % of the parent university total. In our sample, among the units that gain the most of their size (highest Q_m^z) this share ranges also between 1.6 % and 24 %. Thus, relative size of the unit seems not to be commanding factor.

Figure 4. *Impact of size on the conjoint teaching and research efficiency in Medical Science domain. Panel left, total academic staff of the university. Panel right, the number of enrolled students in the field*



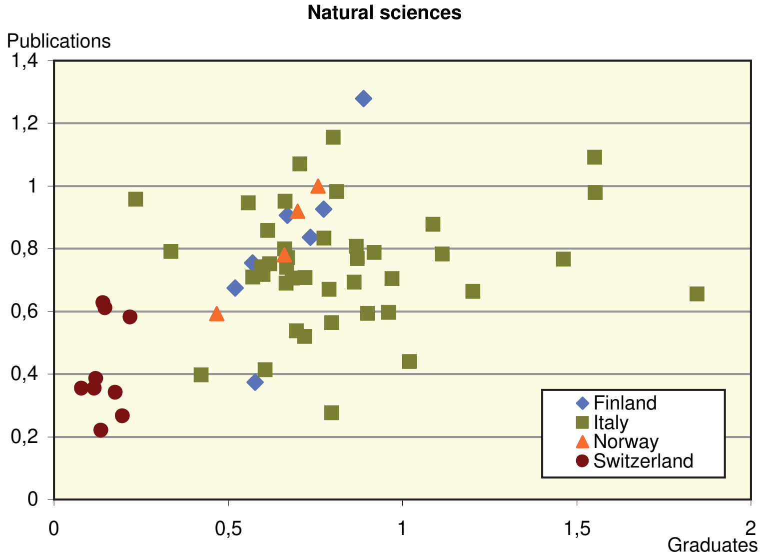
In the panel right the size refers to units own enrolment. The trend appears different, no impact until around 4 000 enrolled students and then increasing trend until 10 000 enrolled students, and no clear evidence on lowering gains. This result supports the "critical mass" hypothesis, such that efficiency of medical schools could be improved by increasing their absolute size. Of course critical mass alone does not guarantee high efficiency levels. However, interdisciplinary co-operation over other schools or departments within a university gain also some support, but not globally, they are clearly dependent on the local setting on disciplines and facilities that is beyond our data.

Natural Sciences

In each sample country the publication rate in Natural Sciences has a rather wide spread. The average number of ISI articles being 0,7 per academic employee, the Swiss schools have the lowest rate, but in no single country universities appear completely different in publication activity. The number of graduates follows the same country wise patterns as in the other Swiss schools with lowest number of graduates per academic employee, Finland and Norway with somewhat higher number of graduates and Italy having the widest spread of graduate rates, up to three fold to Finish and Norwegian ones. In spite of this, two Italian schools, Sannio and Milano Bicocca, have the graduation rate less than 0.4, close to their Swiss peers.

As a whole, the Figure 5 suggests that there is actually some kind of positive correlation between graduation and publication rates. A large number of graduates are also reflected in ISI publications, thus there is no evidence on particular gains for doing either or.

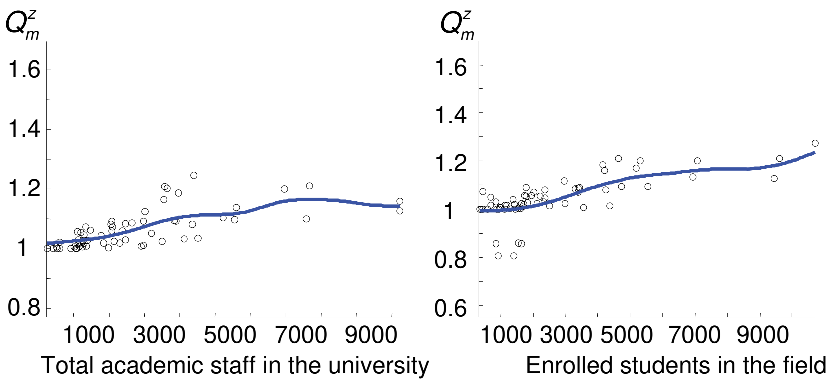
Figure 5. The ratios of graduated students (horizontal axis) and publications (vertical axis) to academic staff in Natural Science domain



Both panels in Figure 6 imply positive impact of size on the conjoint production of teaching and research. Thus, it seems to be beneficial - measured in number of outputs - to units in Natural sciences to work in the larger university complexes. This is quite natural, when we take into account the heterogeneity of Natural Sciences. Both research and teaching in e.g. Mathematics, Physics, Chemistry and

Statistics are overlapping, thus favouring multidisciplinary work. The same pattern is visible in enrolled students. However, in this case we have also some evidence of an unfavourable impact of the small size on efficiency; all the five small units scoring less than unity are Swiss universities, although also two relatively small Swiss universities, Lausanne and Fribourg, have scores above unity.

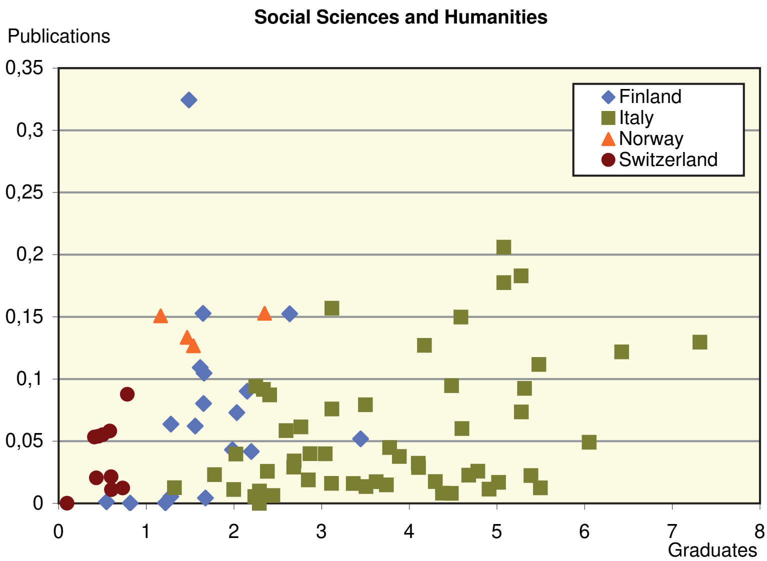
Figure 6. *Impact of size on the conjoint teaching and research efficiency in Natural Science domain. Panel left, total academic staff in the university. Panel right, the number of enrolled students in the field*



Social Sciences and Humanities

In Social Sciences and Humanities publication rate varies evenly among the sample universities between 0 and 0.15 ISI papers per academic employee (Figure 7). The only unit that differs clearly from this pattern is University of Kuopio (FIN), that has no research in Humanities. At least in Finnish data this point makes a clear difference (see Chapter 13 in this volume), as in social sciences researchers use approximately half of their effort to publish in international journals, in Humanities less than 15 percent of the time is devoted for that purposes. Graduation rates in this field vary a lot by country and also within countries. Some Italian universities reach four times higher rates than Finnish universities on average and the average graduation rate in Italy is seven times higher than the Swiss one.

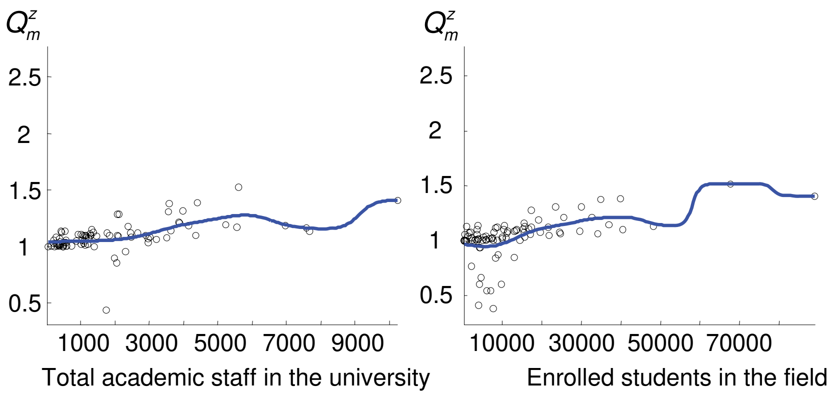
Figure 7. *The ratios of graduated students (horizontal axis) and publications (vertical axis) to academic staff in Social Sciences and Humanities domain*



Unlike in other domains considered in this paper, Social Sciences and Humanities do not show any positive correlation between research and teaching outputs. Relatively high publication rate may well get observed with low or high graduation rate universities.

For the Social Science and Humanities field we observe generally increasing gains of the size in both panels (Figure 8). There is some evidence for the U-shaped development in the left panel for the staff size above 6 000. Thus, Social sciences and Humanities seem to gain increasingly from the larger university complexes, but up to the certain limit. Concerning the number of enrolled students in the field, there are no efficiency gains of university size when the units have less than 1 000 enrolled students. Within this range, we even have 13 non-Italian units that actually seem to have disadvantages of their small size. For the higher number of enrolled students in the field, increasing efficiency gains prevail practically over the whole range.

Figure 8. *Impact of size on the conjoint teaching and research efficiency in Social Sciences and Humanities domain. Panel left, total academic staff of the university. Panel right, the number of enrolled students in the field*



14.5 Conclusions

In this paper we have introduced for the first time evidence on impacts of unit and university size on efficiency by discipline in a sample of European countries. We have exploited the Aquameth dataset in its' current state to introduce the necessary methodology and to draw the first exploratory results.

The size of the university may be associated with the absolute size of the unit or with the size of the academic environment. We measured the former with the number of enrolled students in the field and the latter with the size of academic staff in the parent university. It is generally assumed, that researchers, departments and other microlevel units in a university gain from interdisciplinary environment. Our results generally support that view in all the disciplines. The gains are usually rather modest, when the university total faculty size is less than 1 000 academics, but increases faster at least until 6 000 academics. There is some evidence concerning the Medical Sciences, that they cannot exploit gains from interdisciplinary environment that well in very large parent universities. Anyway, the impact of the parent university's size is never negative in our sample. The evidence concerning the unit's own size points to the same direction. This is quite natural, as the disciplinary classification we have used is rough enough to cover interdisciplinary gains also within a group. In Engineering and Technology, Natural and Social Sciences and Humanities some small units clearly lose some of their efficiency due to their low number of enrolled students. Even if these results do not tell anything about actual efficiency levels reached, in Engineering and Technology the units with between 15 000–25 000 enrolled students gain the most on their size, in Medical Sciences efficiency increases the most after 4 000 enrolled students, in Natural sciences the number of enrolled students steadily increases efficiency. In Social Sciences and Humanities the units with enrolment from few hundreds to one thousand are worse off than the larger units, which experience higher efficiency gains along the increased enrolment figures.

Aquameth project has tried to solve inherent problems in international comparisons of higher education. The target has been in creating a dataset and conduct analysis on institutional level, so that important features of the systems are not lost in national aggregates. The summer 2007 coverage of the database is 10 countries and 394 universities. It includes in total 42 different measures, of which 8 are further divided in four disciplines of Engineering and Technology, Medical sciences, Natural Sciences, Social Sciences and Humanities and non-classified data, giving totally 82 separate variables.

The comparability and coverage issues in this kind of data set are obviously hard to solve, but we have shown that with careful selection of the methodology and objects of the study, also heterogeneous datasets can be useful. We have used discipline level data on four countries, Finland, Italy, Norway and Switzerland to study how the efficiency and unit size are related. The university production function in our efficiency model is simple, academic staff in a unit is used to produce both graduate degrees (teaching) and refereed ISI articles in journals (research). This simple model allows us to compare unconditional efficiency to one conditioned by the university's size. In this setting, we compare two otherwise similar efficiency measures of the unit, giving us reasonable estimates of the role of size on efficiency regardless of the data comparability issue. We have also ended up using robust order-m efficiency scores, which reduce the impact of outliers, curse of dimensionality and sample size bias in the data and the model.

The analysis of independent publications rates and number of graduates to the number of academic staff reveals country wise differences especially in graduation rates. Variation within Italian universities is generally large, with the lowest number of graduates per academic employee approximately at the same level as the Finnish peers in the sample. However, in a considerable number of Italian universities the graduation rate is a multiple. One could claim that these universities are specialized in teaching, but this is not necessary the case, in all the other disciplines, than Social sciences and Humanities, the academic staff in these schools also published more papers than in schools with low graduation rate. Publication rates appeared more evenly distributed country wise, jus in Medical Sciences the academic staff in Finnish universities a is clearly more active than in the other sample countries.

Our results are still explorative and mainly show how heterogeneous international datasets could be used to analyse productivity differences. The present version of Aquameth dataset will be constantly developed and we hope to be able to include in analysis universities from other countries and use more recent data and/or from longer time period. To go on in further detailed international comparisons, data comparability becomes a greater issue. A lot of work has been done within Aquameth also in this field, but due to structural differences in university systems, a European wide consistent dataset is not a realistic target. Rather the target is to create a well documented dataset and a network of researchers that create potential for well justified comparisons and further development of university systems.

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SUMMARY OF THE BOOK

PRODUCTIVITY OF WELFARE SERVICES PROVISION: RESULTS FROM RESEARCH ON EDUCATION

This book reports results arising from research on the productivity of education services provision. The report starts by over-viewing productivity in the entire welfare services sector. It proceeds by describing the production process and discussing the importance of the education services in the economy as a whole. Following that the text explains how the productivity of the welfare services is measured, and what are the main problems and challenges in carrying out that measurement. Finally, the book reports findings on productivity research for six different school types from Finland and abroad.

The report shows evidence suggesting that the productivity of the welfare services in Finland is relatively high in comparison to international standards. However, welfare services productivity growth in Finland has been negative between the mid 1990s and 2005. One reason for observing that poor development is that during the mid 1990s Finland was affected by a serious economic recession and that increased the number of welfare personnel. And that increase did not ultimately result in a corresponding increase in production. However, part of the increase in personnel may have led to an improvement in the quality of service provision in a way that is not recorded in the statistical production indices used in the analyses.

Regarding other services, productivity has been decreasing in health and social services as well as in some educational services, such as basic and high schooling. In contrast, productivity has been increasing in vocational schooling and universities at least during the new Millennium.

The study also finds that productivity differences between production units (municipalities in many service types) are small, on average about 5 percent. This implies that major productivity increases cannot be achieved by imitating the best practices from the most productive units. Achieving that would likely demand improving the production process across the country.

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