CHAPTER 16

The contribution of Research Universities in solving "Grand Challenges"

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A CHANGING WORLD

Obviously, the world is changing rapidly, and not only for the better: Grand challenges for society are arising and demand solutions. Some challenges can be foreseen, some may occur without warning. When societal problems can be predicted, responsible governments have to address their solutions. Early research has to contribute to meeting upcoming challenges.

The European Union's foresight and forward-looking activities have a long tradition: societal trends are analysed, and knowledge gathered by these analyses becomes part of planning for the future ("The world in 2025, Rising Asia and socio-ecological transition").

As the public authorities increasingly aim at analysing and addressing future challenges, public expectation about the relevance of science and research of universities will change: the abstract aim of increasing the GDP will not be an end of research, but research should rather focus on tackling "themes" and achieving solutions to societal problems. Such a strategy might also enhance the interest and enthusiasm of researchers and the public alike (Winckler & Fieder, 2005). As the arising challenges are multidisciplinary, they cannot be the subject of a "single" scientific approach, but will need different contributions from various fields in order to be addressed fully. Of course, the traditional Humboldtian goal of "education through science" (*Bildung durch Wissenschaft*) will not change.

Broad and transdisciplinary themes are identified by the European Commission (2009) in the report "The world in 2025". In this document the Euro-

pean Commission also addressed the rise of a "multipolar world", with new players such as China. In the report *Preparing Europe for a New Renaissance. A strategic view of the European Research Area*, (European Commission, 2009a) the European Research Area Board (ERAB), a high-level advisory board to the European Commission addressed, for instance, the following grand challenges (European Commission, 2010):

- climate change
- health care
- ageing societies
- reduced availability of resources (energy, water).

In the report "Realizing the New Renaissance", (European Commission, 2010), ERAB recommends immediate, mid-term and longer-term actions which were developed and divided into four broad fields: unite the European Research Area in a global context; strengthen the interplay between science, society and politics; enhance open innovation; guarantee that the European Research Area delivers excellence and cohesion.

The solution of the Grand Challenges calls for a "paradigm shift in what the role and place of science should be" (ERAB 2009a, p. 9). The interaction between science and society and the collaboration of the public with the private sectors in the form of open innovation, play a major role in the strategic view to be developed. As research and innovation are particularly important to solve grand challenges, society should be ready to raise expenditures in the E.U. for R&D to 4% to 5% of GDP.

Tackling the new themes will also require new ideas, discoveries and the creation of talents. To realize the potential of research, the way research is done should be changed too. Strengthening the European Research Area should help to establish this new renaissance and should be marked by free movement of people (mobility of staff and students) and ideas ("open science"), and also by promoting "high-risk/high-gain" research.

Yet, unfortunately, the question remains, whether European universities will be willing to foster the idea of a "New Renaissance" as universities seem to be too much prisoners of their past.

UNIVERSITIES AS PRISONERS OF THEIR PAST

Today, universities play a central role for higher education and frontier research in Europe. Obviously, universities and their contributions are needed for creating a new renaissance.

However, European universities are still very occupied with their own affairs. This inward orientation may hinder a more goal- or theme-oriented approach to research:

- European universities are mostly organized along national and regional borders, although the Bologna and Lisbon process have helped to reduce the fragmentation *of the university landscape* within Europe. Yet, there is still too much provincialism within (Continental) European universities. There is still no real Europe-wide labour market for scientists and educational staff, as language, legal and practical barriers still exist. About 97% of graduates working today as faculty members at European universities had all their employment in the country in which they received their Ph.D. (Winckler, 2010).
- Universities are usually too *hierarchically organized*, a fact that strongly hinders creativity (Sawyer, 2006). It diminishes research opportunities for young scholars.
- The proportion of *blue sky research* may be too high. This does not mean that basic research should be reduced, but that research activities should be bundled along themes. The volume of blue sky research should be retained in the future, but research in line with tackling grand challenges has to grow over-proportionately. Research on grand challenges will be more and more the prime target of European research funding.
- Total fertility rates in Europe dropped after the "baby boom" in the 1960s to 1.6 children per woman in the year 2010 (source: population reference bureau; http://www.prb.org/DataFinder/Geography/Data.aspx?loc=413). Low birth rates will not only affect the health care and the pension system, but will confront universities with a *decrease in the number of domestic students*. Attracting the best brains from abroad, however, requires a degree of openness and internationalization of universities in (Continental) Europe which they do not yet possess.
- Universities indulge in an *idealistic* and often *self-referential* way of doing research. A pragmatic approach towards research should be adopted: universities should accept the interest of society in new research themes, especially when meeting grand challenges.
- Last, not least: *resources and money* are *not used efficiently*. In the sciences, for instance, cooperation between scientists across institutional borders may lead to better use of resources. There is a need for more cooperation between universities for better use of resources and for an increase in the quality of higher education (Taylor, 2011).

Will universities perform better when rankings and quantitative measurements of the quality of research such as impact factors gain importance? In general, of course, competition may lead to a more efficient allocation of resources. Yet there are reasons to doubt that ranking competition improves the efficiency of the university sector: the performance measurements of universities with respect to rankings often suffer from poor data quality. There is

too much noise in the data (Bookstein *et al.*, 2010). In addition, rankings may have a language bias as illustrated by the *Times* Higher Education Ranking: *In the ranking of 2010, universities in English-speaking countries perform on the overall score better than universities in non-English-speaking countries (non-English-speaking countries: N = 78; mean avg score = 55.6; English-speaking countries: N = 122, mean avg score = 63.6; ANOVA = 22.56 P < 0.01).*

Furthermore, ranking competition may decrease the much needed openness of science, as cooperation across universities gets impeded. A comparable problem may arise by "over-emphasizing" impact factors and citations as a quality indicator for publications, as the impact of a journal predicts the number of citations that an article receives (Perneger, 2010). In addition, in cultural markets anything of average quality may emerge as top ranked if it is driven by social influences (Lorenz *et al.*, 2011)

Universities should not become like professional football clubs, chasing after the big names only and forgetting how to form new research teams between universities working on upcoming research themes.

TOWARDS A NEW WORLD OF RESEARCH AND INNOVATION

The structure of scientific research is on the way of a radical change. Very likely, this change may allow researchers to address themes of arising global challenges more effectively. What is needed is that universities move from the *ivory tower* to a more universal approach to research. Such moves might increase research output, but will also bring new challenges to traditional research institutions and funding bodies.

This trend is already indicated by the increasing share of researchers in business and enterprises: In the economically leading countries (measured by the overall size of GDP) Canada, China, France, Germany, Italy, Japan, Russia and the U.K. (Figure 1) (no data available in this form for the U.S., only amounts of budgets are known, Figure 2), with the exception of the Russian Federation and the U.K., the full-time equivalents of researchers in business and enterprises have conspicuously risen during the last 10 years. Concerning research staff in higher education institutions (universities), there is also a rising trend in Canada, France, Italy and for the U.K. In Germany, China and the Russian Federation, the number of full-time staff in higher education institutions seems to remain stable. However with the exception of Italy and the U.K., the rise of the number of researchers in business and enterprise is much steeper than for the higher education sector. Particularly in China and Canada, the number of researchers in business and enterprise increased strongly compared to the other sectors. Governmental research and research in private nonprofit organizations remain in all countries on a very low and increasingly marginalized level. For the U.S., R&D investment in business enterprises rose steeply from 1981 onwards (Figure 2).

Figure 1

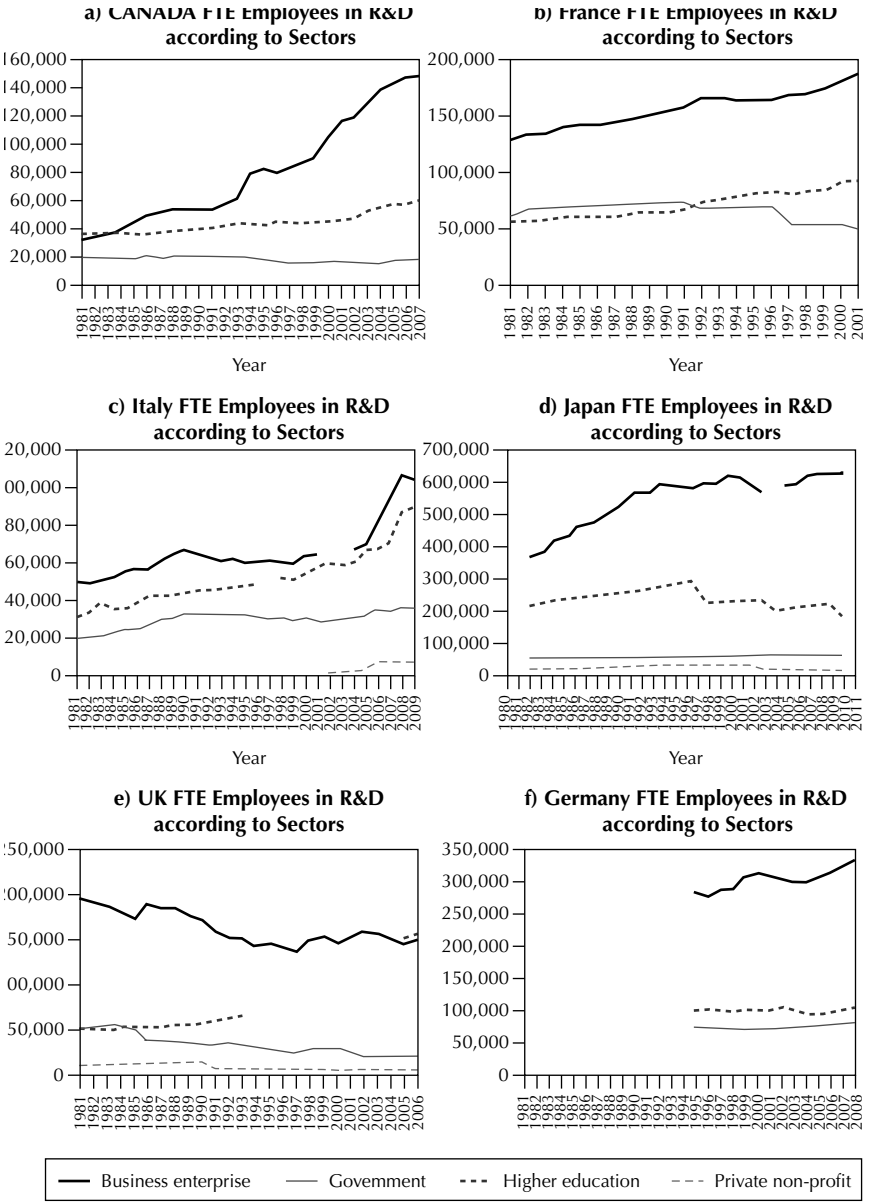

a) CANADA FTE Employees in R&D according to Sectors
b) France FTE Employees in R&D according to Sectors
c) Italy FTE Employees in R&D according to Sectors
d) Japan FTE Employees in R&D according to Sectors
e) UK FTE Employees in R&D according to Sectors
f) Germany FTE Employees in R&D according to Sectors
Year
Business enterprise
Govemment
Higher education
Private non-profit

Figure 1

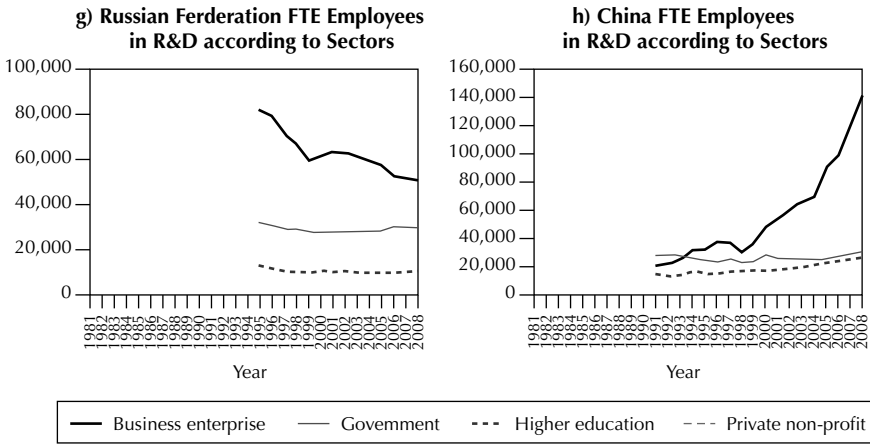
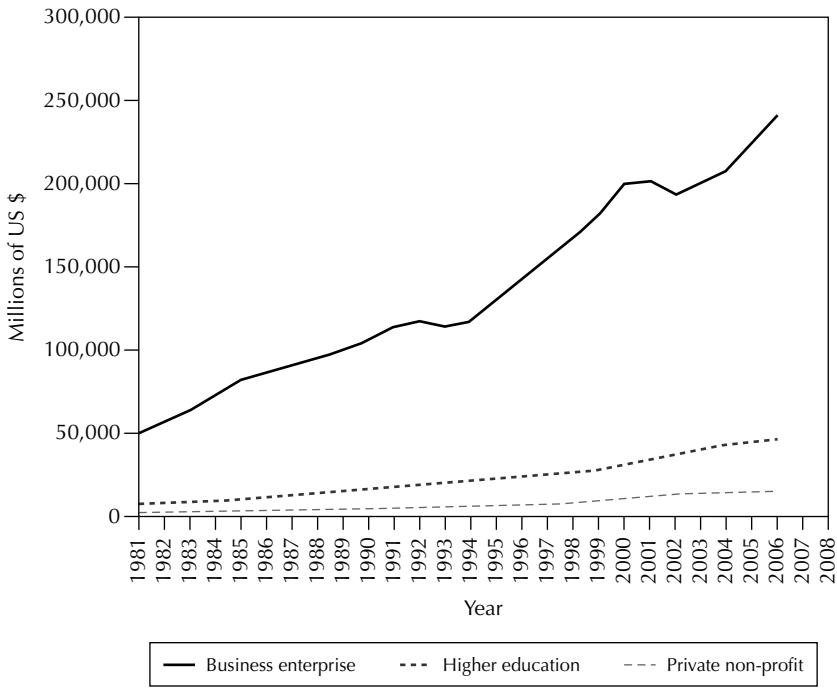


Figure 2 : US R&D Investements in Mio. $



Yet not only the number of researchers and financial resources in the business sector rises overproportionately, but also open innovation seems to gain importance as a new form of cooperation. The paradigm of open innovation assumes that firms can and will use external ideas as well as internal ideas. The research boundaries between a firm and its environment have thus become more permeable; innovations can easily be transferred (Chesbrough, 2003). Over the past few years, open innovation has become a concept on which more and more enterprises rely (examples: http://en.wikipedia.org/wiki/Open_innovation).

In addition the more radical concept of "crowd sourcing" has gained importance: Tasks are being distributed to a number of individuals often working and solving problems in their free time. *The best known example for crowd sourcing might be Wikipedia itself,* although the founder of Wikipedia, Jimmy Wales, refuses the term "crowd sourcing" for Wikipedia.

Both open innovation and crowd sourcing may represent examples of how research universities may behave in an open system where information flows freely. Universities will increasingly act like "open clubs" attracting part or fulltime co-workers who research and publish for a limited time for a university. Especially the science parks around universities will constitute a potential, mobile recruiting field for short-term jobs at a university.

As a consequence, the borders of universities may become very permeable. Non-professional scientists may engage themselves in research and may publish with a university (a kind of academic crowd sourcing). It is up to the universities to use this potential in the future. An excellent starting point could be keeping and intensifying the contact with alumni. Universities should think about what they are able to offer to potential non-professional "outside researchers" (for instance a sophisticated further education). This may boost the reputation and visibility of universities.

All these new developments such as "open innovation", "crowd sourcing" and "open science" may foster the tackling of the "grand challenges", for which societies have an interest and, thus, will provide financial means. Research funds should be prepared to finance these newly emerging structures of research, e.g. a certain proportion of the finances should be used to support "open science startups".

Additionally also higher education and teaching are on the way to a dramatic change: Via Apple's iTunes numerous podcasts of courses are offered completely for free. Stanford, particularly, is highly active on iTunes. Furthermore Stanford also uses iTunes to keep in touch with the community interested in the affairs of the university.

Another impressive example for open education and open teaching is MIT, due to the MIT OpenCourseWare. Per definition, "MIT OpenCourseWare" (http://ocw.mit.edu/index.htm) is "a free publication of MIT course materials

that reflects almost all the undergraduate and graduate subjects taught at MIT". Via OpenCourseWare MIT offers materials and information, but not any degree or certificate.

As a consequence, access to knowledge becomes free and everyone who wants to gain knowledge and who wants to prepare him/herself for a study can do so, without paying (high) fees. To gain a degree or certificate, however, students have to enrol at a university.

It can be assumed that many more examples of open teaching content will be soon on the net and will enable people around the world to get in touch with the newest scientific development, again potentially enabling people outside the traditional academic borders to engage in science and research. Additionally, by increasing the proportion of "open education" the general participation rate will also increase. Furthermore, new technologies will flood the educational sector. Rupert Murdoch already signalled that News Corp is to make a significant new push into the education technology market (*Financial Times*, 25 May 2011, p. 19).

A CHANGING ROLE FOR UNIVERSITIES

As borders of universities may become more permeable and as more and more research opportunities and data are no longer restricted to specific research groups, innovation activities can be conducted worldwide by many researchers and even by the general public. For many scientific fields, data can be downloaded from the internet completely free of charge; the main restrictions are the existing bandwidth of the internet and the organizations and documentations of scientific data repositories (*Science* special issue on data, *Science* 331, 639-806). But, despite these technical obstacles, everyone who is capable of analysing data can do so, as also the tools of analyses are available for free and in open source (the free statistical program R (The R Project, 2011) that started to develop into a general tool for analyses of data in all fields, is a perfect example of the new trend). The problems that arise in this context are: who pays for gathering and storing of the data and who pays for fast internet connections, who owns the data and who guarantees the compliance with ethical principles when using the data?

However, despite these problems, the positive effects might outweigh the negative ones by far: Data are not lost on "private" servers or computers, but could be re-used for many different research issues. Many more scientists, especially from developing countries, could use data for scientific publications without paying for their use. This trend will foster research and innovation as many more "brains" can work on scientific questions and problems and overall, data and knowledge becomes more sustainable.

Ultimately, the concept of "open science" will prevail: New knowledge will be generated and disseminated rapidly by giving up the rights over using this knowledge. "Open science" facilitates the generation of further knowledge, helps students in moving towards frontier knowledge and boosts the innovation system. The benefits of "open science" stem from the significant positive external effects it creates.

The increasing share of business and enterprise research may point to a trend that might be even stronger in the future. Research has become so open and feasible that it will increasingly be done outside universities; external organization will play a more important role in knowledge production, challenging the traditional role of universities. As mentioned above "crowd sourcing" might become common in academic knowledge production.

Due to this reason, the education and particular graduate education at universities will become more important. Increasingly universities may become certifying agents for those who participate actively in research elsewhere and marketing institutions to bring research more directly to society and to the economy.

There are two trends corroborating this line of argument in the U.S.: (1) the rise in the proportion of FTE researchers working for business and enterprise, (2) the growing rate of proposal submissions from "non-research-intensive organizations" which points to the importance of research outside traditional structures: E.g. *during the 5 years between 2000 and 2004, the proposals from research intensive organizations increased by only 42% whereas proposals from all other organizations increased by 58% (National Science Foundation,* 2007).

Furthermore, the budget allocation since 2002 of national science funds in the U.S. reflects the growing importance of research outside of "traditional research organizations".

All these trends challenge the traditional roles of universities, as more and more frontier research and more and more research concerning the grand challenges will be conducted elsewhere.

At the moment, universities seem to fail to satisfy the demand of knowledge societies, particularly in the case of Ph.D. education (*Nature*, 472, 261). A Ph.D. is traditionally produced along narrow academic criteria and often narrow scientific fields. Hardly any interdisciplinary research takes place. Research labs are in a herd competition with each other only. As a consequence, in virtually all countries, there is a relatively slow increase in job offers on the job market for Ph.D.s. In Germany, for instance, only 6% of the Ph.D. graduates end up in full-time academic positions for an unlimited period. In Japan, the situation is even harder for Ph.D.s. Highly qualified young scientists represent a "treasure of human capital" that lies fallow, but the conclusion of Mark Taylor (2011) in *Nature* might be too pessimistic: "Reform the Ph.D. system or close it down." Particularly those young scientists dropping out of the academic world could foster scientific thinking and a com-

mitment to research elsewhere in society or in business: Highly skilful and educated young scientists, who "spread" into societies, could be compared to the social descent of well educated persons from the higher social strata in the 18th and 19th centuries, a fact that, among other reasons, may have fostered the industrial revolution (Clark, 2007).

What might be the consequence for universities? Instead of evaluating future trends in research more effectively, Continental European universities pursue similar, traditional aims, adopt quite the same measures to achieve these aims and fail to occupy new and "ecological" niches. Making a university unique and fit for the future requires differentiation and a balance between local interest and a global view, especially concerning quality management of education and research. It is not clear how universities learn that cooperation between them will be an urgent need in the future (Winckler & Fieder, 2010).

HOW TO SECURE THE FUNDING OF UNIVERSITIES?

The increasing permeability that will characterize the borders of a university, the enhancement of "open science" and of "open innovation" will make the research university more dependent on attracting public funds. Of course, private donations may complement public money, but private money will more and more respond to the commitment of research universities to tackle "real issues" and to focus on the grand challenges for society.

Universities have to acknowledge that other competitors on the "research market" will come into play, eroding the monopoly rent of doing frontier research. Universities should be open for themes of importance for society, e.g., participating in cooperation with academic, but also with non-academic, organizations in solving the grand challenges. Schumpeterian innovation rents might be earned there. Yet, by moving into this direction, universities need to be less self-referential, more pragmatic and more open-minded.

Securing the funding of a university in the future will also press the university to organize itself more flexibly and less hierarchically.

CONCLUSION

Open Science, open innovation and open education will gain importance. The human potential that will be engaged in research will grow particularly outside the established research organizations, as publications, data and programs are more and more available for free via the internet. It is wise to invest in this growing overall research capacity from a European respectively governmental perspective, particularly to better address the "grand challenges". It is important for research universities to learn to be active in this growing sector. However, that requires a more outward-looking attitude than is common today.

REFERENCES

Bookstein, F., Seidler, H., Fieder, M. & Winckler, G. (2010). Too much noise in the Times Higher Education rankings. *Scientometrics*, 85, pp. 295-299.

Chesbrough, H. (2003). Open Innovation: The New Imperative For Creating And Profiting From Technology. Harvard Business School Press, ISBN: 1-57851-837-7.

Clark, G. (2007). *A Farewell to Alms: A Brief Economic History of the World*. Princeton University Press, ISBN-10: 9780691141282.

Cyranoski, D., Gilbert, N., Ledford, H., Nayar, A. & Yahia, M. (2011). "Education: The Ph.D. factory. The world is producing more Ph.D.s than ever before. Is it time to stop?" *Nature* 472, pp. 276-279.

European Commission. (2009). Directorate-General for Research. Socio-economic Sciences and Humanities *The World in 2025. Rising Asia and socio-ecological transition*.

European Commission (2009a). First report of the European Research Area Board "Preparing Europe for a New Renaissance: A strategic view of the European Research Area."

European Commission (2010). Second report of the European Research Area Board (2010) "Realising the New Renaissance: Policy proposals for developing a world-class research and innovation space in Europe 2030."

Lorenz, J., Rauhut, H., Schweitzer, F. & Helbing, D. (2011). How social influence can undermine the wisdom oft he crowd effect. Proceedings of the National Academy of Science of the United States of America 108, pp. 9020-9025.

McCook, A. (2011). "Education: Rethinking Ph.D.s". *Nature* 472, pp. 280-282.

National Science Foundation (2007). *Impact of Proposal and Award Management Mechanisms*. Final Report.

Perneger, T. V. (2010). "Citation analysis of identical consensus statements revealed journal-related bias". *Journal of Clinical Epidemiology* 63, pp. 660-664.

Sawyer, B. K. (2006). *Explaining Creativity: The Science of Human Innovation*. Oxford University Press, ISBN-13: 978-0195304459.

Science special issue on data (2011). *Science* 331, pp. 639-806.

Taylor, M. (2011). Reform the Ph.D. system or close it down. *Nature* 472, p. 261.

The R Project for Statistical Computing (2011). www.r-project.org

Winckler, G. (2010). "Innovation Strategies of European Universities in the Triangle of Education Research and Innovation". In: Weber, L.E. & Duderstadt, J. D. (eds.) (2010) *University Research for Innovation*, Economica, London, ISBN 978-7178-5797-9.

Winckler G. & Fieder M. (2005). Declining Demand among Students for Science and Engineering? In: Weber, L.E. & Duderstadt, J. D. (eds.) (2005) *Universities and Business Partnering for the Knowledge Society*. Economica, London, ISBN 2-7178-5190-9.

Winckler, G. & Fieder, M. (2010). Kooperation zwischen Universitäten und wissenschaftlichen Fächern. In: W. Mantl, ed. *Phänomenologie des europäischen Wissenschaftssystems*. Nomos Verlag EURAC Research, pp. 303-313.