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Knowledge transfer via cooperative research - How Universities and Universities of Applied Science are positioned in the German research network

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Knowledge transfer via cooperative research – How *Universities* and *Universities of Applied Science* are positioned in the German research network

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Abstract: *The purpose of this paper is to observe the different positions of universities in contrast to universities of applied science (which are the two most important public higher education institutions in Germany) within a research network. The network is unveiled using data of currently ongoing publicly funded projects covered by the 'Förderkatalog' of the German Ministry of Education and Research. Cooperative research is an important channel regarding the knowledge transfer between HEIs and companies. The results show that this is especially the case for universities. Universities of applied science are much less involved in the research network and the universities are in more central positions within the network throughout all four used measures. Additionally the universities show a high level of interaction among each other, whereas the universities of applied science don't. Regarding the spatial dimension of network linkages no more than about 8 percent of the linkages are within the range of one district. And even though a significant difference between universities of applied science and universities regarding the geographical distance of linkages within the research network can be observed, the average distances underpin that first finding because the average distances of 280 kilometer for universities of applied science and 330 kilometers for universities are much longer than expected.*[1]

Introduction: Academia, as stated by Fritsch et al., is considered as a crucial backbone of growth oriented innovation policy. Two main reasons for this are given by the authors: (1) The public education system can be influenced by politics and (2) the public research institutions do have what is needed to innovate, they inherit knowledge (Fritsch et al., 2007). The institutions gather and store knowledge. Additionally they create new knowledge and they transfer that knowledge into the economy. And the importance of HEIs in the latter context seems to increase (Cooke et al., 2007, p. 56). Regarding this work, four channels of knowledge transfer are considered (based on Hamm et al., 2012): (1) basic transfer e.g. publications, (2) human capital e.g. graduates, (3) formation of enterprises, in this case spin offs and (4) via research, e.g. cooperative research. The question to be answered is: How do the different channels through

[1] Part of the Research Project *RegTrans*. The RegTrans Project is funded by the German Ministry of Education and Research. http://www.hochschulforschung-bmbf.de/de/1393.php

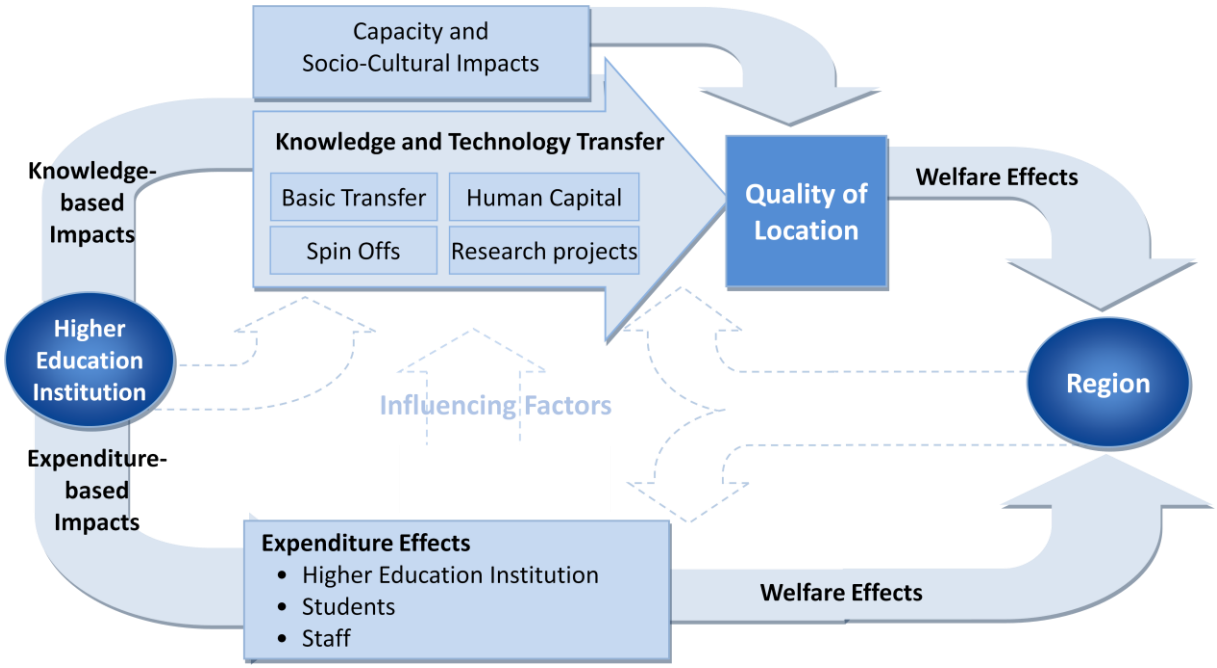
which the knowledge is meant to flow into the economy vary regarding different types of academia? Regarding the German higher education system especially two types of academia can be differentiated. These are the *universities* on the one hand and the *universities of applied science* on the other hand. These different types of higher education institutions (HEI) in Germany show distinctive characteristics, e.g. more application oriented versus research oriented teaching, personnel structure (more research assistance in universities) etc. Regarding the transfer of knowledge two questions (which are interwoven) arise: (1) Does the intensity of transfer vary between the different HEI types? (2) Is the spatial distribution of knowledge different, regarding the two diverging types of HEIs? While in this work only a few things will be said about the channels one to three, the focus is on the fourth channel: knowledge transfer via research.

The paper is organized as follows. At first a literature based model which summarizes the impacts of HEIs on a region is presented briefly. The model is further used to point out which part of the overall effects is examined more carefully afterwards when concentrating on cooperative research. The subsequent section contains the empirical work, beginning with a description of the used data, followed by some information about the methodology used, the analysis itself and the results.

A theoretical model: This work is part of a broader research project. The *RegTrans*[2] project aims to analyze differences of higher education institutions (HEI in the following) regarding the effects they have within and beyond the region of their location. The most central point in the analysis is to observe differences of the knowledge transfer intensity and its range of influence regarding the two most important different types of HEI: Universities and Universities of Applied Science (UoAS in the following). The underlying theoretical model (shown in figure 1) is a result of the wide range of aspects covered in the literature.[3]

[2] See the following homepage: http://www.hs-niederrhein.de/forschung/niers/forschungsprojekte/regtrans/
[3] An extensive description can be found in Hamm et al. 2012.

Figure 1 Effects of HEIs



Source: Hamm et al., 2012

Firstly Hamm et al. distinguish between side effects of a HEI, which one could describe as *supply* (knowledge-based impacts) and *demand* (expenditure-based impacts) side, and influencing factors. The demand side effects contain the impacts of HEIs based on the expenditures corresponding with the construction of the building and expenditures by staff, students and visitors. Typically these effects are measured by Keynesian multipliers, differentiating direct effects, indirect effects and induced effects (see for example Carrol & Smith, 2006). Because there are several studies (see for a survey of studies regarding German HEIs: Stoetzer & Krähmer, 2007) conducting multiplier based analysis this channel is put aside in the following.[4]

The influencing factors (shown in the middle of the figure) are divided into influences from the HEI side, intermediaries and from the side of the region. The HEIs for example might improve the transfer of knowledge with regard to the region by observing and reacting to the needs of companies located in the region (Hamm et al. 2012; Knappe 2006). Intermediaries - for example transfer supporting institutions - might help estimating the chances for a spin-off to succeed on the market and the commercialization potential of inventions. An influence of the region itself affecting the success of knowledge transfer is for example the capability of the companies to absorb and apply knowledge (Christopherson & Clark, 2010, also see Cohen & Levinthal, 1990).

Most important for this work are the knowledge based impacts (the supply side). The transfer of knowledge through different channels or by different mechanisms is content of various studies.

[4] There are also socioeconomic and cultural impacts which won't be described here in detail. Examples can be the impact of students living in the area around the campus on cultural nightlife, theaters etc. Capacity effects capture effects like the central library, offering literature and access to databases licensed by the HEI.

Perkman & Walsh (2007) conducted a literature review in which they focused on distinguishing links between HEIs and industry based on relationships from links based on other transfer channels, like the employment of graduates for example. One conclusion they draw from their review is the high importance of relationship-based mechanisms like collaborative research (Perkman & Walsh, 2007; also see Meyer-Krahmer & Schmoch, 1998, p. 840). Based on the approach of the RegTrans Project four channels of knowledge transfer are differentiated. (1) basic transfer e.g. publications, (2) human capital e.g. graduates, (3) formation of enterprises, in this case spin offs and (4) via research, e.g. especially cooperative research.

It is assumed that the effects primarily influence the perceived quality of the location, which leads to a higher establishment regarding the corporate landscape and population growth (especially of working age). And the better transfer and absorption engage, the higher the resulting effect.

Regarding the mechanism of knowledge transfer via cooperative research the following results for the following analysis are expected. (H.1) The *intensity* of cooperation, counted by the pure number of linkages, should be higher for the universities than for UoAS. Universities are bigger (about three times as much on average regarding staff and amount of students). Especially the financial aspects should play a role, as it is easier at universities to pay research assistants by general budget funding. This in case eases the application process and the phase of post-editing of funded projects. On the hand, professors at UoAS must have worked in some kind of firm before applying as a professor at a university of applied science. This should foster linkages to the economy. (H.2) Regarding the spatial distribution of linkages one can hypothesize that the smaller UoAS are more often cooperating with companies and institutions localized in closer distance. UoAS are meant to provide more application oriented teaching and research. Especially contacts to local companies (internship or thesis in cooperation with local companies) may foster cooperative research projects. (H.3) The positioning of the different types of HEI remains to be identified. The higher intensity regarding cooperative research for universities might lead to a more central position within the network. It has to be seen if clustered sub-networks exist and if these are connected and by whom. Additionally possible cooperation linkages between the different types of HEI, combining basic research and application oriented research, might be detected.

Analysis of university-industry relationships

The FÖKAT: Using data from the 'FÖKAT' (the 'Förderkatalog' of the German Ministry of Education and Research) a research network between companies, institutions and academia is unveiled. This online catalogue contains about 110000 data set entries of direct project funding of the German government (as it does not contain data of funded projects of federal state level, this might be an explanation for the later findings of non localized cooperative projects, as these projects are not especially fostering local cooperation, but cooperation in general). On the other hand, this would indicate that projects fostering cooperation in general do not lead to localized cooperation. The motivation to find local partners therefore seems to be not so great. The FÖKAT is considered the most extensive source regarding what happens with public funds in the German research environment.[5] The analyzed data in this work is restricted to all currently ongoing projects. The resulting set of data contains 22722 data set entries which include information on cooperative and non-cooperative projects. All together these entries cover 8342 projects. 5966 of these are cooperative projects. These are the ones used to unveil the network which in the end includes institutional research facilities, companies and academia. In the network bidirectional linkages are used, as the cooperation leads to what Meyer-Krahmer & Schmoch call *"exchange of scientific knowledge"* in contrast to a one-directional transfer of knowledge (Meyer-Krahmer & Schmoch, 1998).

The FÖKAT contains the partners regarding the projects, as well as the funding volume and the length of the project as information. The length of the project might serve as an explanation for possible outcomes regarding the spatial dimension of the linkages, because partners in short-term projects are more reluctant to accept longer geographical distances (see Broström 2010).

The average time length of the projects in which HEIs are involved (including non-cooperative projects) is 3 years. By calculating a frequency distribution for universities and UoAS it can be shown that the frequency of occurrence around the peak (which is at 3 years) is relatively similar[6] regarding the two types of HEIs with about 25 percent of the projects with a length above and 25 percent below three years. Therefore the length of projects should not be a relevant factor regarding possible differences between universities and UoAS. A second thing one can see in the graph is the big difference regarding the number of projects the different types of HEIs are involved in. The universities outnumber the UoAS by far. Therefore it is very likely that universities in general will gain more central positions within the research network in the following.

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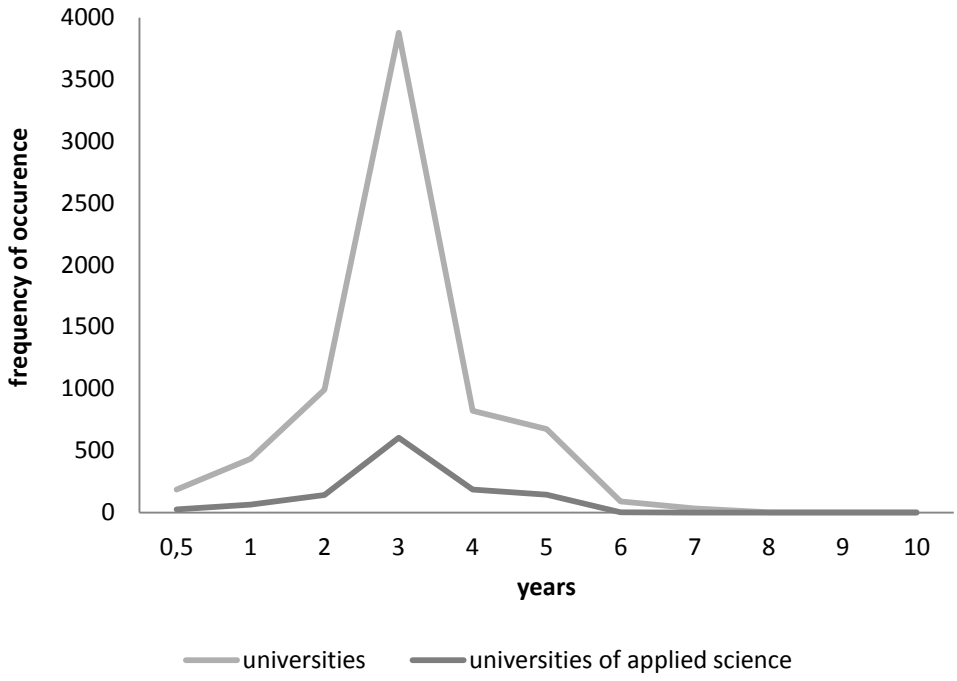
[5] http://www.bmbf.de/de/2762.php (19.02.2013)

[6] Using a factor of 7 regarding the frequency of occurrence does clearly show how similar the distributions are. The observable difference seems to be completely caused by the different amount of projects.

Figure 2 Frequency distribution - length of projects

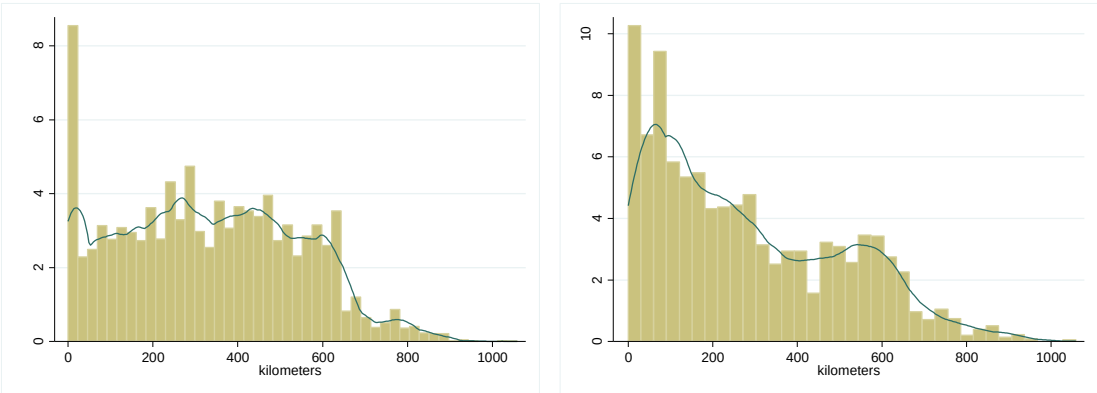


A comment on used methods: Using centrality measures (see Freeman, 1979) such as *degree*, *closeness* and *betweenness* the position of the different HEI types within the network can be measured and compared. Degree-centrality can be used to observe cooperative activity, as it measures the number of direct linkages. Closeness-centrality uses the information on the average path length to every other actor within the network. This way a high closeness-centrality can be used as an indicator for inheriting a position with good access to new knowledge and/or a position which can be used to give impulses to the network that reach all other actors fast. The betweenness-centrality can be used as an indicator for control options within the network, in terms of knowledge brokerage. A fourth centrality measure used in this work is the eigenvector-centrality. This kind of measure does consider the centrality value the neighbors of a vertex have. By doing so it ranks a vertex higher, if it is linked to other vertices with a high centrality value. In other words: You are in a more central position, when you are connected to very central individuals instead of peripheral actors. It can be observed that the centrality measures are significantly higher for universities than for universities of applied science, using a nonparametric Mann-Whitney-U two-sample rank-sum test (because the normality assumption seems to rigid to conduct a standard t-test).

Regarding the localization of linkages there is only a small indication for a more locally clustered cooperation pattern for universities of applied science than for universities at a first glance. Looking at the linkages with UoAS, 8 percent of the linkages are within a district. The corresponding value for universities is 7 percent.

To get more information on the spatial distribution of cooperation linkages the distance between two partners has been observed using the (driving) distance from district to district. Using the information about the distance of 3498 linkages involving UoAS and 40586 linkages with universities involved, the following two different distributional graphs deliver a more detailed insight into the frequency distribution of distances:

Figure 3 Measured distances – Universities (left) and UoAS (right)



To support the theory of UoAS being involved in more locally characterized partnerships, firstly the average distance of cooperation partnerships for the 62 UoaS and 85 universities in the dataset of the main component of the network has been calculated and it has been tested, if the average distance of these two types of HEI differ significantly from each other.[7] The results of the Mann-Whitney test show that this indeed is the case. But with average values for UoAS of 282 kilometers and 329 kilometers for universities and under simultaenous consideration of the length of 886 kilometers (linear distance) from the most northern to the most southern part of Germany this is by far not as localized as expected. Nevertheless one can observe a peak at the first bar (which means cooperation activities within one the district where the HEI is located and a few more in nearby districts).[8]

Analysis and results: The network with all the over 4000 actors and 74000 lines contains many linkages, which are only counted one, two or three times. To reduce the network to a more feasible size and constrict the analysis to the network emerged from more meaningful cooperation linkages (the ones strengthened by more than just a few cooperative projects) the m-slice procedure (De Nooy, Mrvar, Batagelj, 2011) is used.[9]

[7] The distance is calculated from district to district.
[8] Having a short look at the first information already gathered from a survey (addressing Professors at six universities and five UoAS in Germany) that is currently in the field and is conducted for the REGTRANS-Project, it looks like there will be evidence that especially smaller companies (1 up to 50 employees) are cooperation partners within a range of 50 kilometers, whereas linkages to bigger sized companies overcome a greater geographical distance.
[9] In a first step the number of lines were summed up and used as the new line weight (which was 1 for each line before). After that all lines with a weight lower than 3 have been removed and the remaining weakly connected (without any isolates) component has been extracted.

At this point the network consists of 1139 actors (85 Universities and 62 Universities of applied science) with 3622 linkages (with different weights) among them. The excluded actors contain about 12.3 percent of the universities (12 universities in absolute terms) and 39.8 percent of the universities of applied science (41 in absolute terms). Again the difference regarding the centrality values between the universities and the universities of applied science are tested. The results are shown in the following table.

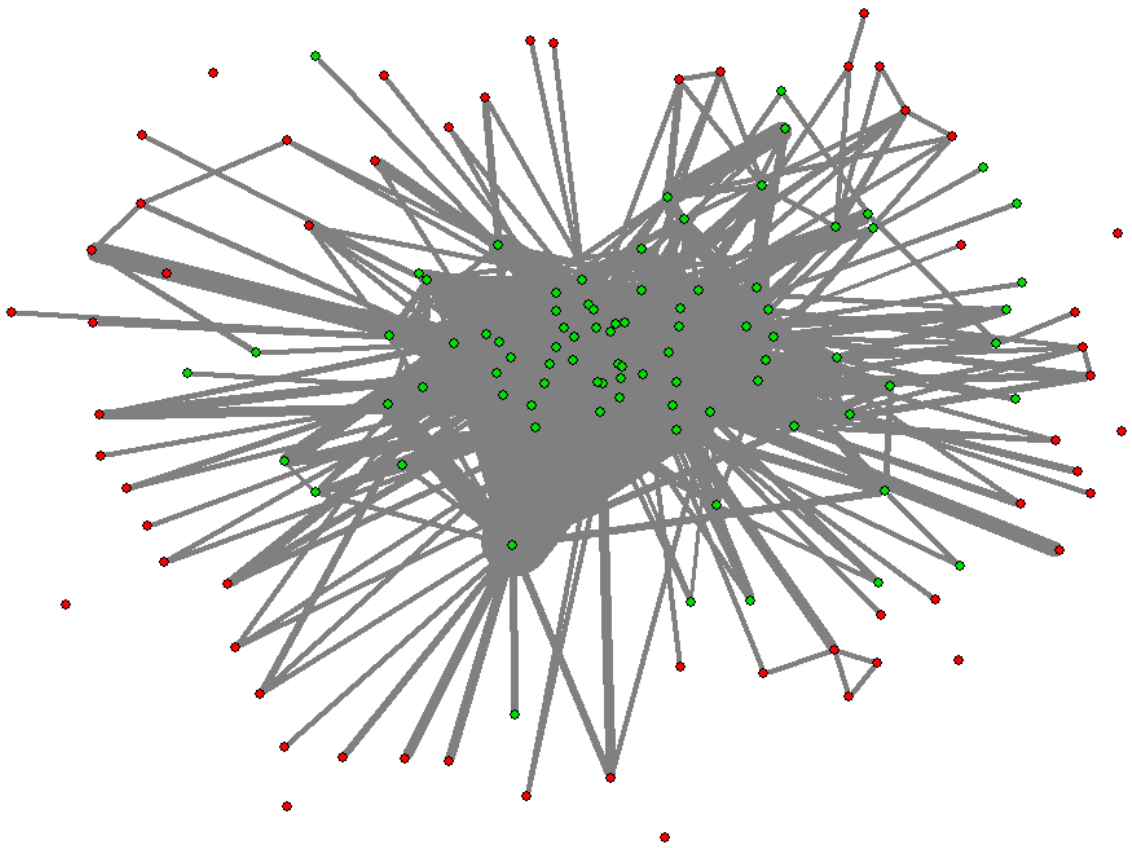
Table 1 Difference of centrality values

variable	1=universities 0=universities of applied science	mean	difference is statistically significant at 1 percent level[10]
closeness	0	.3432	yes
	1	.3828	
betweenness	0	.0008	yes
	1	.0074	
degree	0	3.593	yes
	1	23.70	
eigenvector	0	.0053	yes
	1	.0347	

The network consists of 1139 vertices, which makes the view of the network somewhat confusing. Therefore three partitions of the network have been made. The three partitions include (1) the 85 universities, (2) the 62 UoAS and (3) the 992 remaining actors. The next figure therefore only shows the network without the 992 remaining actors. Whereas the universities (green dots) have many links to each other, the UoAS (red dots) in contrast to this are more or less only connected to universities and not connected to each other. Research in cooperation between UoAS is an exceptional case. The width of the lines indicates the intensity or strength (in terms of number of linkages) between actors within the network.[11] The width of the lines (see appendix for details) show that the technical universities (e.g. Aachen, Berlin, Darmstadt, Munich) are most often in contact with the same partners in much more than three projects. Another detail, which can be observed looking at the network, in many cases the UoAS of a region are connected to the rest of the network via their partnership with the universities of the same region (e.g. UoAS Munich → LMU Munich and Technical University Munich; UoAS for Economics and Management in Essen → University Duisburg-Essen; UoAS Kaiserslautern → Technical University Kaiserslautern).

[10] See Appendix for the corresponding testing tables.
[11] Because it is difficult to make everything visible that is happening within the network within the network, two more figures can be found in the appendix.

Figure 4 Network of Universities and UoAS



Conclusion: Looking at the research network unveiled between actors like universities, universities of applied science, companies and research institutions differences of universities and UoAS could be identified. Regarding the intensity of transfer the number of linkages, the number of projects and the position of actors within the network structure have been observed and compared. Using data from the FÖKAT of currently ongoing research projects funded by the German government it can be seen, that Universities are involved in much more cooperative research projects than universities of applied science. Comparing universities and UoAS regarding the achieved values of degree-, closeness-, betweenness- and eigenvector-centrality significantly higher values for universities can be shown. Universities are in more central positions within the network regarding the cooperation activity, the average length of paths to other actors, the probability to be in a gatekeeper position and being connected to other important actors. Looking at the universities and UoAS only (excluding the remaining actors) it becomes obvious, that universities show linkages among each other much more often than UoAS. The intensity of cooperative research is less distinctive among UoAS as well as with the remaining actors. For many cases one can see that the UoAS are connected to the university network via connections with the local universities. The second question, besides the intensity, was the spatial dimension of linkages between the actors within the network. It has been assumed that UoAS (which are meant to be well connected to regional actors of the economy)

will show a much more localized cooperation structure than universities. Whereas the spatial dimension is indeed significantly more confined in space the average geographical distance (measured in kilometers of driving distance from district center to district center) with a value of nearly 300 kilometers is higher than expected.

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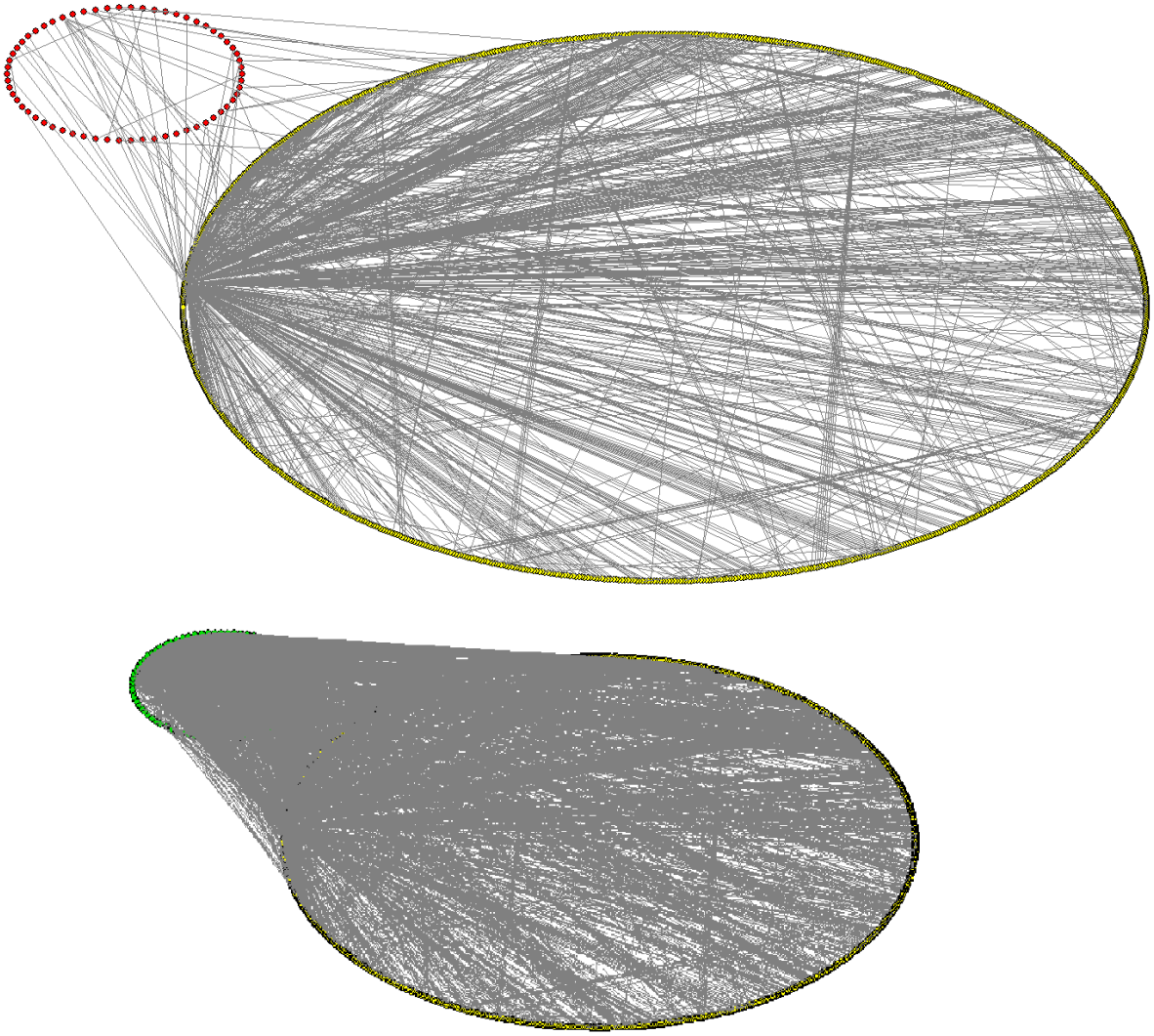
Appendix

Table 2 Testing for differences between Universities and UoAS

```
Summary for variables: close
     by categories of: hstypreg (HSTypReg)

hstypreg |      mean       p50
---------+----------------------
       0 |   .3535192   .359883
       1 |   .4182427   .436003
---------+----------------------
   Total |   .3849101  .3836395
----------------------------------------------------------

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

    hstypreg |       obs    rank sum    expected
-------------+---------------------------------
           0 |       103      6954.5     10351.5
           1 |        97     13145.5      9748.5
-------------+---------------------------------
    combined |       200       20100       20100

unadjusted variance   167349.25
adjustment for ties       -0.88
                     ----------
adjusted variance     167348.37

Ho: close(hstypreg==0) = close(hstypreg==1)
             z =  -8.304
    Prob > |z| =   0.0000


Summary for variables: degr
     by categories of: hstypreg (HSTypReg)

hstypreg |      mean       p50
---------+----------------------
       0 |   .0091902   .007881
       1 |   .0915016   .071804
---------+----------------------
   Total |   .0491112   .012697
----------------------------------------------------------

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

    hstypreg |       obs    rank sum    expected
-------------+---------------------------------
           0 |       103        6973     10351.5
           1 |        97       13127      9748.5
-------------+---------------------------------
    combined |       200       20100       20100

unadjusted variance   167349.25
adjustment for ties      -45.44
                     ----------
adjusted variance     167303.81

Ho: degr(hstypreg==0) = degr(hstypreg==1)
             z =  -8.260
    Prob > |z| =   0.0000
```

```
Summary for variables: betw
     by categories of: hstypreg (HSTypReg)

hstypreg |      mean       p50
---------+----------------------
       0 |  .0004357   .000083
       1 |  .0100347   .004709
---------+----------------------
   Total |  .0050912   .000519
----------------------------------------

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

    hstypreg |       obs    rank sum    expected
-------------+---------------------------------
           0 |       103        7222     10351.5
           1 |        97       12878      9748.5
-------------+---------------------------------
    combined |       200       20100       20100

unadjusted variance   167349.25
adjustment for ties     -460.26
                     ----------
adjusted variance     166888.99

Ho: betw(hstypreg==0) = betw(hstypreg==1)
             z =  -7.661
    Prob > |z| =   0.0000


Summary for variables: Av_dis
     by categories of: hstype (HSType)

  hstype |      mean       p50
---------+----------------------
       0 |  282.8146  264.1155
       1 |    329.13  311.3763
---------+----------------------
   Total |  309.5956  303.4154
----------------------------------------

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

      hstype |       obs    rank sum    expected
-------------+---------------------------------
           0 |        62        3641        4588
           1 |        85        7237        6290
-------------+---------------------------------
    combined |       147       10878       10878

unadjusted variance    64996.67
adjustment for ties        0.00
                     ----------
adjusted variance      64996.67

Ho: Av_dis(hstype==0) = Av_dis(hstype==1)
             z =  -3.715
    Prob > |z| =   0.0002
```

Figure 5 Connections between network partitions*



*Description of the partitions
Red nodes: Universities
Yellow nodes: Firms and other research institutions
Green nodes: Universities of applied science

Figure 6 Network of Universities and UoAS only (differing line width)

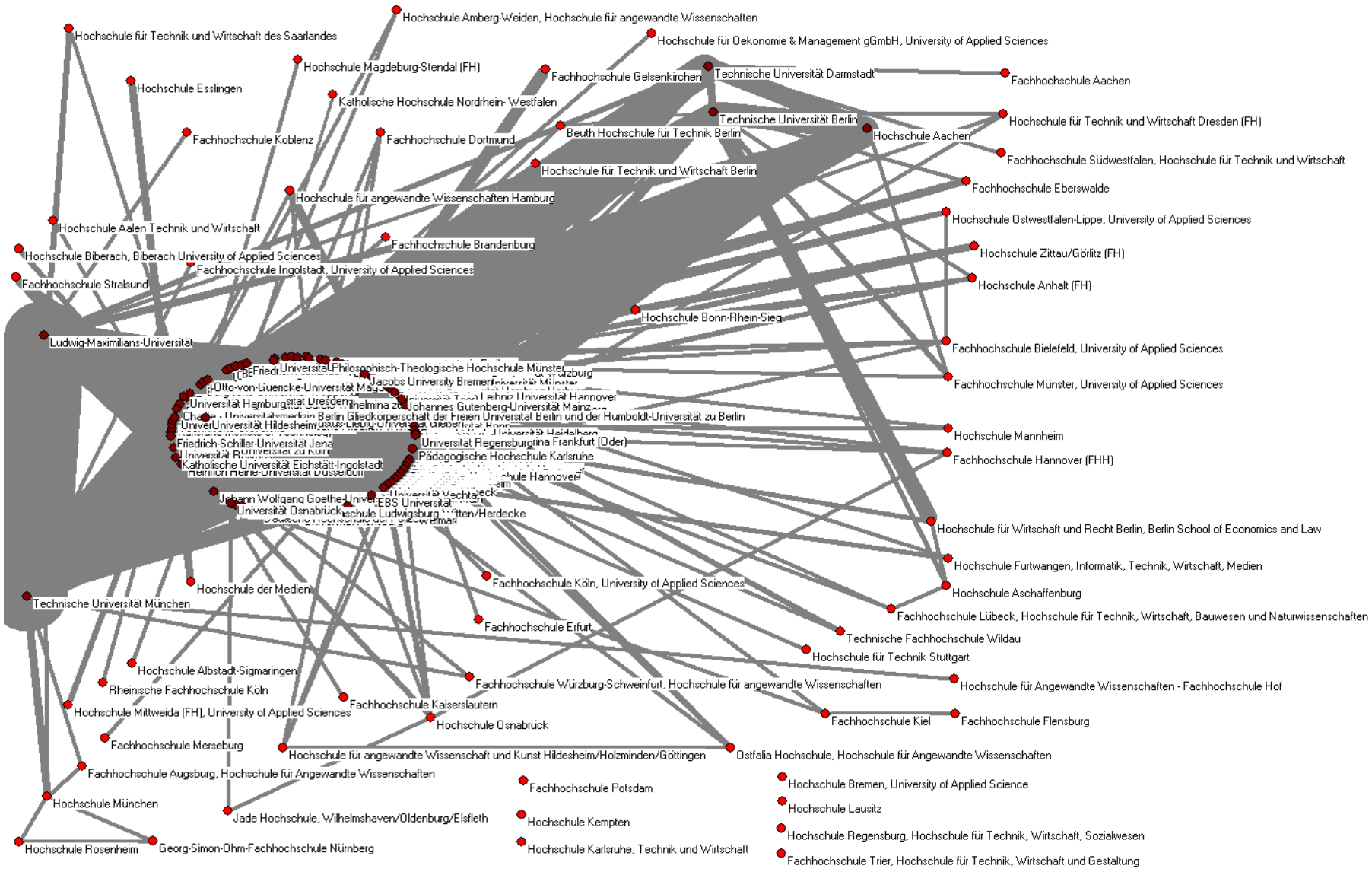
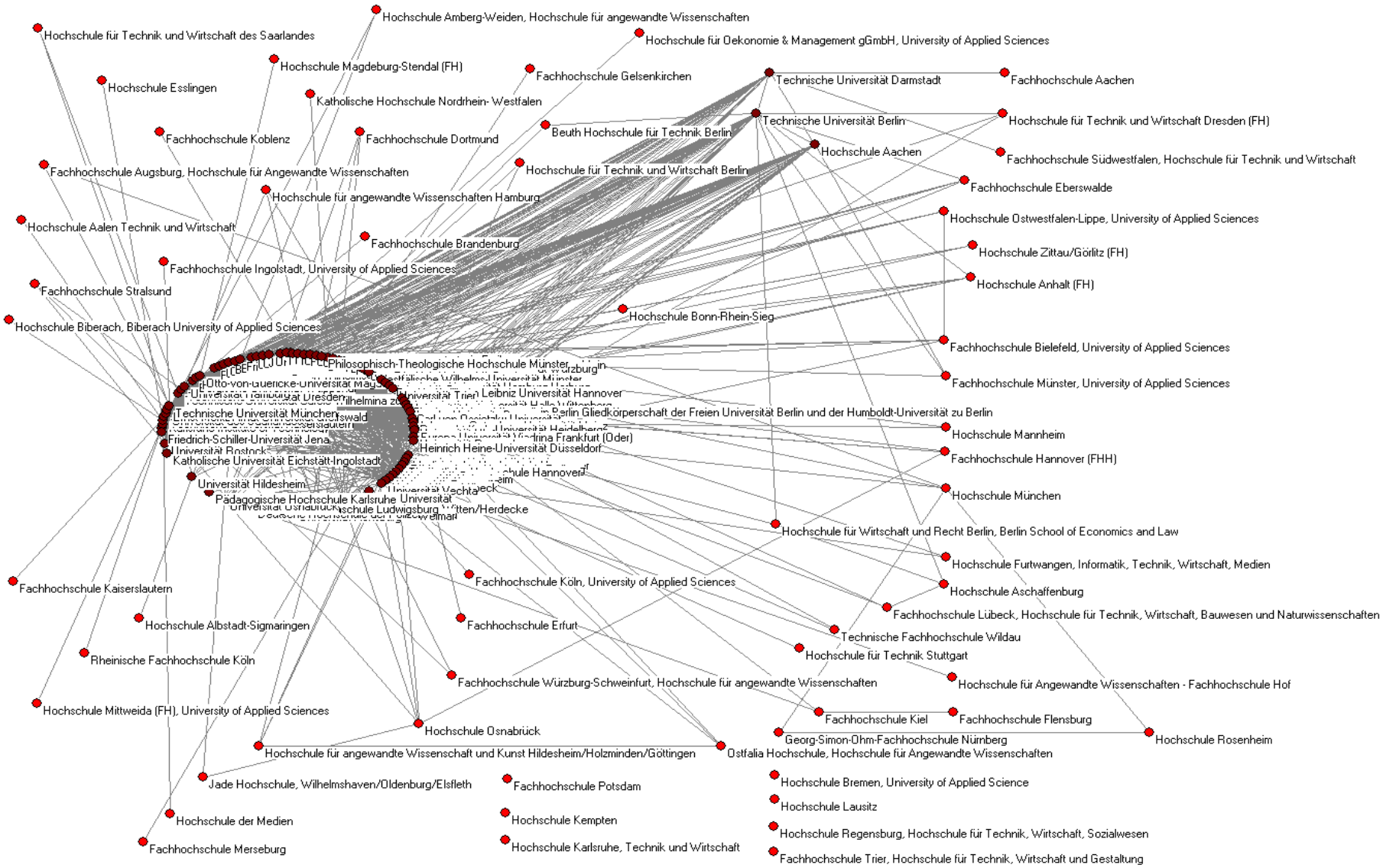



Figure 7 Network of Universities and UoAS only (standard line width)