Probing the Austrian innovation system: twelve case studies of knowledge producing institutions

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Twelve Case Studies of Knowledge Producing Institutions

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Abstract

The paper attempts an answer to the question of why some knowledge creating institutions in Austria are innovative and others are not. To this end a sample of twelve institutions from the research and economic spheres is analyzed and compared. The variables for the analysis are drawn primarily from the notion of a *mode 2 of knowledge production*, based on the work of Michael Gibbons, Helga Nowotny and others (Gibbons et al 1994). Finally, from the analysis of the case studies more general lessons for the understanding of innovative activities in institutions and innovation policies are drawn.

Based on the concept of the knowledge system and a new theoretical approach to the study of such systems, developed by Karl Müller (Müller 1996), a project team at the Institute for Advanced Studies in Vienna set out in 1995 and 1996 to take part in an OECD initiated study program on a seven country comparison of national innovation systems. This paper is an output of work done for the project.

Zusammenfassung

Die vorliegende Studie versucht die Frage zu beantworten warum manche österreichischen Forschungseinrichtungen innovativ sind und andere nicht. Zu diesem Zweck wurden 12 österreichische Institutionen aus dem universitären, außeruniversitären und wirtschaftlichen Sektor analysiert. Ein erheblicher Teil der verwendeten Variablen basiert auf der Arbeit von Michael Gibbons, Helga Nowotny und anderen (Gibbons et al 1994). Abschließend werden einige allgemeine Schlußfolgerungen über institutionelles Innovationsverhalten und Innovationspolitik gezogen.

Diese Studie entstand aus einem größeren Projekt unter der Leitung von Karl Müller 1995/1996 am Institut für Höhere Studien. Dabei handelte es sich um ein OECD-Projekt, das einen Vergleich der Innovationssysteme von 7 Industriestaaten zum Ziel hatte.

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1. Introduction

How are innovations created and diffused in societies? Why are some institutions innovative and others not? What can be done to enhance the innovativeness of institutions? In an era of extension of the global competition from the economic sphere to areas as science and technology or the arts the answers to these questions are of interest for people from all societal spheres. This paper attempts an answer to the question of why some knowledge creating institutions in Austria are innovative and others not. To this end a sample of twelve institutions from the research and economic spheres is analyzed and compared. Finally, from the analyses of the case studies more general lessons are drawn.

The paper utilizes research done during the last two decades along the venues of the notion of systems of national innovation. System concepts of innovative activities have led from technological system approaches (often by historians or science, technology and society (STS) scholars as for example Hughes 1983) to industrial cluster analyses (mainly by economists such as Michael Porter 1990). The notion of the national systems of innovation (here researchers come from a variety of disciplines, see for instance Freeman 1987, Lundvall 1988 and 1992, Nelson 1993) and - most recently - to knowledge systems (Smith 1994). At the heart of the notion of the knowledge system is the distribution power of the system, primarily the distribution of knowledge between universities, research institutions and industry (David/Foray 1994).

Based on the concept of the knowledge system and a new theoretical approach to the study of such systems, developed by Karl Müller (Müller 1996), a project team at the Institute for Advanced Studies (IAS) in Vienna set out in 1995 and 1996 to take part in an OECD initiated study program on a seven country comparison of national innovation systems. The team consisted of the director of the IAS, Bernhard Felderer, the project coordinator, Karl Müller, furthermore Beate Littig, Christoph Hofinger and Peter Biegelbauer from the IAS, Richard Költringer from the Institute for Panel

by the Austrian Federal Ministry for Science, Transport and the Arts with Norbert Rozsenich and Eva Schmitzer as project managers. From the side of the OECD the contact persons were Dominique Foray and Jean Guinet.

This paper is part of the research effort for the above described project on the Austrian innovation system. The methodology of the study was dominated by the theoretical work primarily carried through by Karl Müller and the quantitative Austrian Survey on Innovation, a telephone survey of 504 companies and 202 research institutions conducted in the summer and fall of 1995. Therefore, the rather qualitative aspects of this paper, with its descriptions and subsequent analyses of the chosen institutions, are complimentary to the other parts of the study. The paper therefore is another step towards the overall goal of the whole study, the characterization of the Austrian innovation system.

2. Methodology

Since this paper aims at addressing more general questions on the innovativeness of the Austrian knowledge producing institutions, the selected organizations are covering a wide range of specializations to be found in this country. Since it is a declared task of the study to trace the latest developments among knowledge producing institutions, a number of variables for the project have been drawn from recent work being done by Gibbons et al (Gibbons 1994). The primary methods have been face-to-face interviews and the review of materials describing input and output of the respective institutions. These methods have been complemented by others to be discussed below.

The described and analyzed institutions are four university institutes, three non-university research organizations and five companies. All three groups have been divided into two subgroups, of which one includes the organizations displaying innovative and the other showing non-innovative behavior. Primary selection criteria are four indicators drawn from the Austrian Survey of Innovations and Transfers.

From this set of institutions a number of secondary selection criteria has been used to create the final subset of twelve institutions.

The primary selection criteria for the definition of the innovative and non-innovative group in the case of the university and non-university research organizations are

- the number of projects per researcher,
- the number of publications in international journals per researcher,
- the number of publications in cooperation with others per researcher and
- the self perceived institutional national and international competitiveness.

The secondary selection process for the research organizations has as its goal to obtain

- a broad variety of sizes of institutions and
- a broad variety of specialization of institutions.

The group of seven research institutions are analyzed on the basis of data coming from several, but with a minimum of two, personal, prepared and structured interviews, ideally with at least one junior and one senior researcher. The interviews consist of two parts: one includes half-open and open questions, the second part provides possibilities for the interviewed to express themselves graphically. In the latter part, the interviewed persons place several categories in a two-dimensional space, thereby relating them to each other and expressing their own personal priorities. For all interviews a time period of the last three years was chosen as reference.

Additional information has been compiled from project descriptions, publication lists, mission statements, etc. Moreover, in the case of the four university institutes, graduate students were asked in personal, prepared and unstructured interviews about their opinion of the institution.

The primary selection criteria for the definition of the innovative and non-innovative group in the case of the companies are

- self-perceived national and international competitiveness of the company and
- number of product, process and organizational innovations.

The secondary selection process for the companies has the goal to obtain
- a broad variety of sizes of companies and
- a broad variety of sectoral specialization of companies.

Analogous to the research organizations the data collection for the company sample consists of similarly structured interviews and of additional information in the form of company histories, business reports, etc.

The selected samples of research institutions and companies are described in tables 1 and 2. As anonymity has been promised to the interviewed persons, not only names have been omitted, but also the disciplines in which the institutions are involved are not described in a detailed manner.

Table 1. Selected Sample of Research Institutions

Type of Research Institution	Innovativeness	Field	Size
University Research Institutions	Non-innovative	Economics	Medium
	Innovative	Technical/ Architecture	Small
	Non-innovative	Technical	Medium
	Innovative	Biology/ Chemistry	Large
Non-University Research Institutions	Innovative	Philosophy	Small
	Innovative	Biology	Small
	Non-innovative	Geology	Medium

Note: Small is defined as less than 8, medium between 8 and 12, large more than 13 scientific personnel. The small personnel numbers are typical for Austrian research institutions.

Table 2. Selected Sample of Companies

Innovativeness	Sector	Size
Innovative	Telecommunications	Large
Non-innovative	Transport	Large
Non-innovative	Banking	Large
Innovative	Plastics	Small
Innovative	Gardening	Small

Note: Small is defined as less than 200, large as more than 500 employees.

As a next step, data from the Austrian Survey of Innovations and Transfers have been enriched with descriptions of the institutions' histories, specialization, budgets, projects, products, etc. This information has been used to create a set of questions for further probing of the institutions in the form of the already mentioned interviews. Main areas of interest for these interviews are:

+ recent product innovations (input/output analysis),

+ process and organizational innovations (in case of the research organizations mainly equipment and project descriptions as well as analysis of time spent on a variety of activities),

+ interconnectivity with the institutions' environment,

+ self-perceived (by interview-partners) factors hampering or fostering innovations in their specific environment,

+ relationship between financing and likelihood of being innovative,

+ capability of institutions to adapt to changing environments,

+ qualification and job transfer of personnel,

+ transfer processes between companies and research organizations.

3. Descriptions of the Analyzed Research Institutions

4.1 University Institute A:

The institute is located in Vienna. It has been founded in the early 1970s, was merged with another institute later on and separated again a few years later. It consists of a personnel of eleven, including nine researchers. The institute has a specialization in a comparatively narrow subfield of economics. The main output of the institute is teaching.

Although the specialization of the institute is close to real life phenomena, there is virtually no cooperation with industry - or any other institutions for that matter. Only two projects have been administered by the institute during the last five years. The low level in interconnectivity was significant also in respect to cooperations with researchers outside the institute, which were practically not existent. The little scientific work done was administrated by each researcher on his or her own. All types of interactions, with the exception of informal contacts, were classified as low by the interviewed personnel. Publication output was low, too. Published articles are mostly to be found in national non-refereed journals.

The only area were the institute's output is significant is teaching. During an average term around 300 students take part in courses of all kind (Proseminare, Seminare, Übungen etc.) - lectures (Vorlesungen) not counted - given by the institute. More significantly, in a typical term up to 60 master thesis have been produced by the institute's students over the years - a number that is somewhat lower at the moment. In stark contrast, only two or three dissertations are finished per term. Interviewed students suggested that it is due to the number of thesis writing students that the average time a student is granted for help with and evaluation of research is quite low in comparison to other institutions at the university. This, according to the interviewed students, attracts a wide variety of students, who all have one thing in common: they want to get their degree the "easy" way.

Despite the concentration on teaching, innovativeness in this area seems not to be higher than in comparable institutions at this university. The number of new courses per year is not significantly different from other social science institutes. The only field where innovativeness is fairly high are teaching techniques, which, however, are developing accordingly to the rising standards of the university.

Teaching was also named the single most important factor why the research output of the organization is so low. The second factor hampering innovative activities named by the institute's personnel was the scientific qualification of the researchers, which was deemed too low.

4.2 University Institute B:

The institute is part of a medium sized university in Vienna. It consists of one professor and six assistants. The institution has a long history, which reaches back to the latter half of the 19th century. Since the late 1950s structure and size of the institute have stayed the same. The institution is specialized in a subfield of architecture. It is heavily teaching oriented.

The total number of students taking courses at the institute was not determinable as estimates reached from 5-700 per term. The number of master thesis completed at the institution was unclear, too. Estimates ranged from 15 to 50 per term. Whatever the true numbers are, the teaching pressure certainly is high.

With the notable exception of one assistant, who incorporates computer technology into the field, innovativeness is generally low. This is true for teaching, where innovations rarely seem to occur, as well as for research, which seems to be poor - again with the exception of the already mentioned assistant.[1]Publication activity

[1] Several experts suggested that it might be problematic to use terms as "innovation" or, even worse, "research" in the field of architecture. Most of them agreed, however, that it is possible to use these terms as long as one changes one's concept of what research means for an architect. More specificly, research here seems not to be only the search, generation and recombination of reproducible knowledge, but also the very process of constructing a new and innovative building, which incorporates knowledge of all kinds. This knowledge, so the argument, is not "just" technology, but is the product of inseparably related applied science.

in general is rather low, new methods and theories were not introduced and new topics do not seem to be approached in a fairly regular manner. Projects are carried through, but, with few exceptions, begin and end with student's works on the topic. Especially the students judged the institute very critically, emphasizing that comparable institutions at the same university were more active, open-minded and innovative.

The interconnectivity amongst the personnel of the institute is low. Moreover, there are almost no cooperations between researchers from the institute and researchers at other institutions. The only way in which the personnel communicates with the outside world, besides teaching, is via the commercial construction office of the headperson. Even here, the influx of new ideas seems to be limited. The opinion of the interviewed students and other data suggest that the only exception, again, is the one assistant who not only has studied abroad, but cooperates lively with other institutions.

As the most prominent barrier to innovativeness one person gave the teaching pressure and low number of personnel, the other the teaching pressure and lacking money for research.

4.3 University Institute C:

The institute is situated in Vienna. It consists of two professors and seven assistants, one of which is working on his master's degree. The institution had existed in pre W.W.II years with a single professor and was re-instituted in the late 1950s. The organization featured the same headperson from then on until the early 1990s. When this professor went into retirement, it took five years to select a new headperson. The specialization of the institute is in a comparatively broad technical field.

The main output of the institute is teaching. Around 400 registrations in courses of all kind per term have been counted, lectures (Vorlesungen) not included. Innovativeness in teaching seems to be above average. This is most visible in the

category "forms of presentation", where students at the institute are more actively involved in the learning process than at comparable institutions. This has been suggested by the two personnel interviewed as well as the students who have been asked. In addition, the course topics are changing fairly regularly. However, still in the realm of teaching, the used methods and theories seem to be non-innovative, i.e. they are neither new for Austria nor the university.

The output in research is decidedly less impressive. Projects are carried through mostly alone, sometimes not in the realm of university life, but privately. Accordingly, interconnectivity is rather meager. Publications are average in number, but most of them are of low profile, printed in small unrefereed journals or newspapers. Practically no new methods or topics could be found in research. Nevertheless, a few topics are classified as having been new for Austria or the university at the time of introduction. All interview partners had high hopes concerning the new headperson, who is said to have a sizable record in research.

As most important barrier to innovativeness number and qualification of personnel has been given. Number two was the teaching pressure.

4.4 University Institute D:

The institute is located at a large university town in the South of the country. It has been founded in the mid 1960s. Having lived through a period of rapid growth, the organization became smaller after the former headperson had left the institute in 1992, taking part of the personnel with him in order to establish a company specializing in medical services. The institute now consists of two professors, ten researchers, six technicians and more than fifteen persons working for specific projects on a work contract basis. The larger part of the research done at the institute is administered by the teaching assistants and students working at their Ph.D. To gain tacit knowledge, a sizable effort is made to gain access to post doctoral students from foreign countries.

The institution is specialized in biochemistry and medicine. The interview partners define the main task of the organization as research. One person emphasized the wish to engage less in teaching as he has to do now. The teaching responsibility at the institute is not large compared to other institutes in the sample, but it is substantial.

Austria's knowledge base in biochemistry recently has been judged to be particularly weak in a recent evaluation of the "Österreichische Biochemische Gesellschaft", facilitated through experts of the 'European Molecular Biology Organization". The press release of the team emphasized that in comparison to other small Western European countries most of Austrian research is far from international best practice standards.[2]

The institute has a high output level when it comes to research. Not only is the number of publications large, but the articles, which are the largest part of the total publications number, are all published in international journals, predominantly of US origin. A number of research technologies has been transferred directly from the US, which is leading research in the life sciences by a large margin with a publication output of 40.5 % of the major journals in the field in 1980-84 and 39.8 % in 1985-89. [3] Moreover, the institution has recently patented two innovations Europe wide. A number of incremental innovations on scientific apparatus can be counted, predominantly measuring devices of all kind. A few innovations are more than incremental, they could be classified as significant improvements of machinery. Most of these innovations are given to companies in exchange for free - and, as a result of the improvements, more functional - instruments and machinery. Finally, a prototype of a photometry device has been developed recently.

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[2] It is interesting to see that both interviewpartners at the institute suggested one factor to be responsible for bad research practices in Austria that was mentioned in the report of the Biochemische Gesellschaft, too - several weeks before the report was published: low personnel motivation and qualification due to a wrong personnel policy. (See "Biochemische Forschung nicht konkurrenzfähig", in: Internet, APA-Net Science Week, 1995-12-11, http://www.apa.co.at/scripts/depot/swe)

[3] In comparison, the distant second was the UK, who produced 10.3 % and 10.4 %, respectively. Austria has produced 0.61% of the articles dealing with the life sciences in the major journals between 1980-84 and 0.59 % in the years of 1985-89. For the latter period Austria is ranked as number 23, which means that most OECD countries feature a higher publication output, including the majority of small Western European countries. All figures are drawn from Braun, Tibor et al, "World Sciences in the Eighties: National Performances in Publication Output and Citation Impact, 1985-89 versus 1980-1984, Part II. Life Sciences, Engineering, and Mathematics", in: Scientometrics, Vol 31, 1(1994), p.7.

This high level of innovativeness goes hand in hand with a high level of interconnectivity towards researchers abroad and in Austria. There is also a significant interconnectivity with respect to companies, most of which are Austrian. All publications that have been counted were cooperations. The interactions with scientists from outside the institute was high, with all types of interactions present - from formal to informal, from cooperations to presentations. As can be inferred from what has been said, the institute is strongly oriented towards the United States. This goes so far that organizational communication and culture are similar to what one can find in US academic life. Especially communication tools as for example 'brown bag lunch series" which are best scientific practices in the States have been imported.[4] This might be explained by the fact that one qualification criteria for newly hired personnel is that the person has to have research experience in foreign countries. This experience has been gathered in all cases but one - this person was in the FRG - again the US.

The interview partners saw innovation barriers especially in three areas: lacking personnel qualification and motivation, bureaucratic immobility at the federal level as well as the university level and a teaching responsibility deemed to large. Both persons added that the motivation of people who could not be fired or even evaluated were at times low.

[4] Other readers who have been exposed to US research institutions will know this tool under another name. The name 'brown bag lunch series" is used at the renowned Massachusetts Institute of Technology (MIT) for informal talks given mostly, but not only, by graduate students who thereby inform the local research community over lunch about their ongoing research. The lack of such a device might be a reason why Austrian researchers often do not know what their peers are doing research on, or worse, why they at times do not even know who their peers in a given field are.

4.5 University Institute E:

The institution is located at a medium sized Viennese university. It was founded in the 1920s. Presently it consists of one headperson and six assistants. The institution is specialized in a subfield of biology.

The institute does not stand alone. It is linked to two other institutions, forming a "cluster" (for the concept and a comparison of different clusters see the next section, "Analysis of Research Institutes"). There have been long-standing relations with one of the other two organizations, a non-university research institute, which has been founded in the mid 1970s and was headed by the same person for almost 20 years. The new headperson of the university institute is also going to take over the non-university institute in mid 1996. The new headperson is the same professor who is the founder and director of the third institution of the cluster, a non-university research institution in the direct vicinity of Vienna, which works closely together with some of the researchers at the university institute. Whereas the university institute combines teaching and research functions, the two non-university institutions are purely research oriented. All three institutions are concentrating on applied research.

The functions of the organizations are for most purposes clearly separated. Personnel is shared only between the two larger organizations, the university institute and the newly founded non-university research institution. Therefore, it is for the purpose of this description possible to separate the university institute from the two others.

In general, the innovativeness of the institution is high. The most impressive part of the institute's work is the research performed there. Methods and research topics have been introduced that were new not only for Austria, but for the world of science itself.

The institute's field of specialization is dominated by the USA. The global situation in the life sciences has been depicted in the description of university institute D. Another discipline with relevance for the institution's work is chemistry. Here the

States are the world's leading nation, again, but with a much smaller margin. 23.5 % of world publication output originates in the US, Austria is ranked as number 23 with an output of 0.49 %.[5] Most Western European small countries are ranked higher than Austria.

In 1995 thirty-eight articles and books have been published by the small institute in German, English, Spanish, Portuguese, Russian and Hungarian. All publications have been cooperations. Accordingly, the interconnectivity level of the institute is high with respect to all categories in the realm of science. The headperson of the institute did not only come from a foreign university, but also still is professor at a university in a third country. As could be expected, cooperation especially in project work is intensive - in an ongoing project five institutions in two countries are working together. Linkages outside the science system do not seem to be particularly strong, despite the fact that large parts of the research performed can be classified as applied science.

Innovativeness in teaching is quite high, too. New methods and topics have been introduced. Seminars have not existed in the curriculum until recently. Practical work is now performed in small groups by the students. Teaching pressure is comparatively high: approximately 260 students are registering for courses given by the small institute. There are no master thesis written at the institute, but at least ten dissertations per year (a fact explainable out of the regulatory system of the university).

Both interview partners gave as main barriers to innovativeness the low qualification and the low willingness of personnel to cooperate. One person felt strongly that people who could not be fired only on rare occasions were motivated to work hard. Moreover, both suggested that the teaching pressure in general was high.

[5] Austria's publication output declined in chemistry - as in life sciences - over the 1980s. When in 1980-84 0.52 % of world publication output was generated in Austria, between 85-89 the number declined to 0.49 %. All figures are from Braun et al, "World Science in the Eighties: National Performances in Publication Output and Citation Impact, 1985-89 versus 1980-1984", in: Scientometrics, Vol 29/3 (1994), pp.327.

4.6 Non-University Institute F:

The institute is part of a larger non-university research organization. It is situated in a large town. The institute was founded as a small research group in the late 1970s to be raised to the status of an institute in the early 1980s. Over time it doubled its size, but still is small by any standards, featuring a headperson and four scientific personnel. The institution's main focus is basic research and to a lesser extent applied research in an interdisciplinary field between the humanities and social studies as well as natural and technical sciences. It is mainly research oriented.

The interdisciplinarity of the personnel is above mean levels even for comparable interdisciplinary institutions and finds an expression in the fact that the institute forms a cluster with two other organizations. These institutions have specialized functions and structures decidedly different from the discussed organization. One small institute has been established in the early 1980s at a university and has a pure teaching function, whereas the other larger one is a high-tech education center, built up recently under the auspices of an organization which is part of the Austrian neocorporatist social partnership structure.

Despite the differences in the type of output, it is difficult to distinguish between the "products" of the three organizations, because personnel from one institute is represented in another. Furthermore, the research done at the institutes is regularly influenced by events taking place in one or both of the other institutions. Therefore, the output evaluation will be done for the whole institutional cluster, with qualifying remarks as to the center of the activity described.

To put it in a nutshell, the output of the three institutes is as large as is their innovativeness. With respect to research, publications are regularly either articles printed in international journals or books published by renowned houses. Most of them are directed to an international audience. The topics as well as the types of research cover a wide field. Especially interesting is the openness of the researchers for new technologies, which leads them, in cooperation with foreign scientists, to innovative

projects. Whereas some projects develop practical problem-solving capacities, others are concerned with purely theoretical questions.

With respect to teaching, output and innovativeness of the institutions is high, too. The small university institute addresses around 700 students per term, lectures included. Approximately 7000 students registered with the high-tech education center in 1995. The teaching techniques at this institute are state of the art; virtual reality, the Internet and creative usage of computer tools of all kind are on the program of the organization. While technology transfer was particularly heavy from the US, original adaptations of technology have been done. Furthermore, solutions found for problems in the education center most likely will spill over to the realm of university life. The training center itself is not only growing fast, but also develops new skills with each new task.

The levels of interconnectivity for the institutional cluster is high in all respects. Linkages to other countries are strong. Of particular relevance for foreign contacts are the USA, which is explainable - amongst other factors - by the dominance of the States in the area of communication and computer technologies of all kinds, with which the institutions, especially the high-tech education center, are concerned. In addition, linkages to national research institutions are strong, too. The headperson of the non-university research institute has advisory functions to a series of bodies in the Austrian research scene. Furthermore, contacts exist to federal and state bodies as the non-university research institute is heavily engaged into contract research. Finally, linkages to corporations exist, although primarily through the larger education center, as technology there is not only imported and diffused, but also developed.

4.7 Non-University Institute G:

The institute is located in a large town and is part of a larger research organization. It has been founded at the end of the 1970s, was reorganized in the late 1980s and merged with another institution in the early 1990s. It presently consists of a scientific personnel of 13, which makes it the largest institute in the sample. The institute is specialized in two fields of science in which Austria's position, again, has declined over the 1980s. The Austrian share of world publication output in the fields of physics and geosciences has gone down from 0.46 % to 0.42 % for the time spans of 1980-84 and 1985-89, respectively.[6] This, however, might have only indirect implications, as the institution is not basic science oriented. Quite to the contrary, its work is focused on services. Research is confined purely to applied science.

Whereas the output proper of the institute seems to be average, its innovativeness is meager. Topics, methods and theories mainly are imported from other institutions, frequently from foreign countries. Regularly they are adapted as to suit the circumstances, but the innovations are incremental only. As might be expected, publication activity is low. One interview partner explained the low number of publications by pointing at the fact that the research done was contract research. The contracts do not only not include publication activity, but sometimes preclude the contractor from publishing results. This explanation seems to hold some truth, given the fact that practically all the financing partners of the institution were in one way or the other close to the state, where interests not to publish research results at times are strong.

Interconnectivity was ambivalent, too. Research frequently was done in cooperation with other researchers from the institution or the umbrella organization. Moreover, contacts with certain partners outside the research system, for example with ministries, were significant and stable over time. However, the frequency of contacts with foreign institutions or university institutes was low.

[6] By a large margin the USA, again, are the country dominating the field with 33.3 % and 33.9 % of the publication output for 1980-84 and 1985-89. All figures are drawn from Braun, Tibor et al, "World Sciences in the Eighties: National Performances in Publication Output and Citation Impact, 1985-89 versus 1980-1984, Part I. All Science Fields Combined, Physics, and Chemistry", in: Scientometrics, Vol 29, 3(1994), pp.318.

One interview partner suggested that one barrier to innovativeness was the qualification of the personnel. Both persons were not satisfied with the umbrella organization the institute was part of. They especially criticized the degree of bureaucratization of this larger organization.

4. Analysis of the Research Institutions

It should be mentioned that, due to the small sample size, the results of the analysis of the research institutions can be seen as indicators pointing at a possible correlation between certain factors. Certainly they can not be proof for such correlations.

One of the first results of the research leading to this paper was that the original classification in university and non-university institutions in two cases was not sensible. Two of the seven research institutions, institutes E and F, formed organizational structures, which, along the notion of industrial clusters (see for example Porter 1990, pp. 287) here will be identified as "clusters" of institutions. In these cases the analyzed research institutions do not stand alone in their efforts to fulfill their purposes. Both identified clusters consist of three institutes fulfilling distinct purposes, which are described later under the subheading of functional differentiation. In both clusters one institute seems to have the function of a coordinator, thereby in one way or another 'leading" the other two. These two institutes, one university and one non-university research institution, shall here be identified as "core institutes".

A third institute split its capacities without forming a cluster. One part of university institute E has left the organization in order to form a company supplying medical analysis services. Presently, the company has no linkages to the university institute.

Due to the fact that the two core institutions are more interesting for analytic purposes, one non-university research institute originally targeted for description has not been analyzed further.[7]Another reason for reducing the research on the originally targeted institute is that the headperson of the institution first was not available for a prolonged period of time and then postponed meetings so that an interview was becoming impossible due to time conflicts with the research schedule for this project.

As a consequence of this, the sample of research institutions now has changed as reflected in table 3. In order to make the formal functional differentiation of the institutions visible, the category "function" has been added. This category identifies institutes as core or, alternatively, as "single" institutes.

Table 3. Final Sample of Research Institutions

Type of Research Institution	ID	Function	Innovativeness	Field	Size
University Research Institutions	A	Single	Non-innovative	Economics	Medium
	B	Single	Innovative	Technical/ Architecture	Small
	C	Single	Non-innovative	Technical	Medium
	D	Single	Innovative	Biology/ Chemistry	Medium
	E	Core Institute	Innovative	Biology	Small
Non-University Research Institutions	F	Core Institute	Innovative	Philosophy	Small
	G	Single	Non-innovative	Geology	Large

[7] However, despite this concentration on the analysis of the core institutes, there has been a sizeable effort to gather data on the other institutes of the two clusters. The main objective for this was a description of the relations these organizations featured.

Already incorporating this reclassification, table 4 shows the results of a first comparison of the 7 analyzed research institutions.

Table 4. Comparison of Research Institutes

Type and ID	Univ. Inst. A	Univ. Inst. B	Univ. Inst. C	Univ. Inst. D	Univ. Inst. E	Non-Univ. Inst. F	Non-Univ. Inst. G
Innovations: Output	-	-	-	+	+	+	-/+
Output Classification	teaching	teaching	teaching	R, D, E, teaching	R, D, teaching	R	service
Innovations: Equipment	-/+	-	-	+	+	+	-
Functional Differentiation	low	low	low	high	high	high	high
Leadership	passive	passive	passive	active	active	active	ambiv.
Interconnectivity	low	low	low	high	high	high	ambiv.
Financing	mono	mono	mono	diverse	diverse	diverse	ambiv.
EU Grants	1/0	1/0	1/0	4/2	1/1	2/1	1/0

The results of the analysis show, as was intended, two extreme groups, one innovative, the other not. Only one institution - non-university institute G - is ambivalent in more than one of the seven aggregated categories.

The category "output (product) innovations" is an aggregate of the number of output innovations in a number of areas from new seminar topics, articles or projects to patents and prototypes per time period per researcher. The "output (product) classification" is done along the standard categories of basic research (R), applied science or development (D) and experimental development (E). In addition, (technical) services and teaching were added. "Equipment (process) innovations" consist of the usage of new, mostly telecommunication devices such as the Internet, but also computers and machinery specific to a certain discipline. The category "functional differentiation" stems from the original idea to measure organizational innovations.[8]

[8] This idea has been dropped due to the fact that Austrian research institutions are mostly miniscule in size: It is truly difficult to trace organizational innovation in a research unit of five persons, two of which are non-scientific personnel. However, it is possible to make a judgement on the grade of functional differentiation between

The category is an interpretation of interview partner's characterizations of the specialization of the institution's personnel. "Leadership" is a rather soft category with a self-explanatory name. When it became clear that the management-style of the person at the head of the research institution had a larger than expected influence on the personal as well institution's innovativeness, the category "leadership" was added. "Interconnectivity" is an aggregate of the number and nature of coproductions with other researchers in- and outside of the institution. The category "financing" is a measure for the diversity of funding possibilities utilized by the institution. "Mono" represents funding overwhelmingly coming from one source, whereas "diverse" represents funding coming from a number of sources. Finally, the two figures of the category "EU grants" reflect how many applications the institution has sent to Brussels in an effort to take part in the Fourth Framework Program and how many applications have been successful, respectively.

It is not surprising that with the exception of one institution the output (product) innovations, the output classification and the interconnectivity are clearly dichotomous in the sense that one can identify two extreme groups. After all, these categories are linked to the original selection criteria - and therefore just are an indication that the data of the Austrian Survey of Innovations and Transfers are valid.

Nevertheless it is surprising to see indications for a in some cases that direct, in other cases more indirect, correlation between innovativeness and the other factors, most of all the aggregated categories functional differentiation, leadership and financing. Among these three the single factor that seems to explain most of the innovativeness of research institutions is leadership. On the one hand, the one institute that is the least innovative of the seven was without a headperson for five years. On the other hand, two of the three institutes that are most innovative are headed by charismatic persons and all three headpersons are displaying active management styles. Moreover, whereas two of the three innovative institutes had dynamic mission statements (which were given out by the headpersons), none of the interviewed

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personnel even in a small organization. I owe this idea to Barbara Sporn, who has used the variable "functional differentiation" as a factor in explaining successful adaptation processes on the meso-level of universities (Sporn 1995).

persons of the three non-innovative institutes formulated such a statement.[9] To the contrary, the statements of the non-innovative institutions frequently are grouped around know-how and products that are already covered by their previous work ("our main purpose is to teach architecture"), whereas the dynamic statements are often grouped around goals that have to be achieved ("we want to cover ground in this specific area of biochemistry by orienting ourselves to the US research in this field").

Furthermore, there seems to be a correlation between innovativeness and the number of successful applications for financing of research to the EU. All analyzed institutions have sent at least one application to Brussels, but only the three institutions that have been judged innovative have received a positive answer from the European Commission. Before the background of Austrian discussions about the value of EU research funding it might be interesting to know that, rather surprisingly, the successful applicants were also the most critical ones with respect to the EU Framework Programs. On the one hand, in two of the three institutions which had successfully applied for research grants interview partners were highly skeptical about the helpfulness of the money they got, which they described as too little, too late (having received it, as they said, after too much wrestling with the bureaucracy in Brussels). On the other hand, in two of the institutes which had filed applications unsuccessfully, persons had made positive statements concerning the EU research grant system.

In addition, there seem to be connections between leadership and functional differentiation. Not only do the two variables come together in the institute sample, but several interview partners mentioned the coordination function of the headperson as among the most important tasks for this post. Moreover, all of the three innovative institutions carried their functional differentiation so far as to establish other institutions, partially staffed with the original institution's personnel that have specific functions.

[9] This category was again inspired by Sporn's research on universities. She is using the variable "mission" in her analysis of university-structures (Sporn 1995). She emphasizes the importance of a change-oriented mission statement for the adaptability of universities.

In the case of the two innovative institutes in the "small size" category[10], E and F, three institutions form a cluster in a given field. In one case university institute E has teaching and basic research as its main task, the two other institutes are applied science oriented. In the other case, the very small university institute F is purely a teaching institution, one of the other institutions is basic and applied science oriented, the last institution deals mainly with educating mid-career target populations. The third highly innovative institute D has chosen a different strategy of functional differentiation. It remains a single unit, classified at the uppermost section of the category "medium". However, it is structured in five groups according to the specialization of the researchers. Moreover, in 1992 a commercial company was formed by members of the institute. The firm is featuring no linkages to the institute.

There are indications that the category "financing" is indirectly connected to the category "innovations: output" and directly to "interconnectivity" and "output classification". However, the linkages seem to be different from what one might expect. A common wisdom for university researchers could be formulated as such, "a maximum of students brings a minimum of research in a given person-year". Nevertheless, the research suggests that the pressure to teach at times is used as an excuse for little research. Two researchers from non-innovative institute A were insisting that one of the biggest factors hampering research at the institute was the pressure to teach. When students were asked about the institute, they said that the institute was the favorite choice of many students for an "easy" completion of studies at the university. The reason for this: the grading was judged as "soft". The same answer was given by students in the case of the non-innovative university institute B.

Another indication for unexpected linkages between financing, interconnectivity and output was the knowledge researchers had about research funding. In two of the three clearly non-innovative research institutions at least one of the interviewed researchers were not informed about possibilities of getting grant money. However, in all innovative institutions all interviewed people seemed to be well

[10] Consequently, the argument cannot be made that size and degree of functional differentiation are correlating.

aware of old and new choices for gaining research funding.[11] This was notwithstanding the fact that researchers of non-innovative institutes at the same time were clearly more likely to insist they were not getting enough funding for research.

Still another category which seems to correlate with innovativeness is "innovations: equipment". With the exception of university institute A and the one ambivalent non-university institute G, innovative usage of new equipment correlates with innovativeness. Non-innovative usage of new equipment meant in all cases not only almost total ignorance of the Internet, but even more detrimental usage of computers primarily for "mechanical" work as for example as a type-writer substitute. This was especially interesting in the case of the two technical institutes where one would scarcely have expected such a behavior.

One factor that has been originally on the list of categories to be analyzed would have addressed the job migration of the researchers. While there has been a question in the interviews concerning the areas researchers come from or go to, it turned out that the category was not to create a clear picture of how this might influence innovativeness. One of the problems was the size of the institutions analyzed. With a statistical average personnel of nine scientists (8.9 to be more exact), the number of persons entering and leaving an institute even in five years was too small to produce a significant result. Consequently, the category was dropped in the final analyses.

Another question not represented in table 4 is the opinion of interview partners on perceived innovation barriers. This category gave some expected and some unexpected results. On one hand, common wisdom leads one to believe that researchers would give money, personnel and teaching pressure as the most important innovation barriers. In fact, six persons ranked personnel and three persons teaching pressure as number one innovation barrier. Moreover, five persons ranked personnel

[11] One indicator for knowledge about new funding choices was the interviewed person's knowledge about the Fourth Framework Program of the EU. EU-programs are fully accessible to Austrian researchers only since Austria's joining of the EU in January 1995.

and one teaching pressure as number two innovation barrier. This makes the two factors by far the most important factors hampering innovations.

On the other hand, if one looks closer, six of the nine persons ranking personnel as number one or number two innovation barrier stated that the main problem was not the number of personnel, but the qualification of their colleagues. Moreover, several persons mentioned the lack of motivation of researchers who could not be fired due to their contracts (Pragmatisierung). Especially department headpersons claimed not to have enough leeway to direct personnel. Several younger researchers suggested that while they had to work very hard, older colleagues, who could not be fired, frequently neither worked hard nor kept up with new research results in a satisfying way.

One result of the analyses of the data is that one institute, non-university institute G, is not easily to be integrated into the data set. The institution has been rated ambivalent in a series of categories. One might conclude that there is a fundamental reason why this is so.

The decisive difference between institute G and the other institutions might be that institute G is service oriented and therefore different from all other organizations. As the mission of the institute is differing from the mission of the other institutes, one conclusion might be that it should not be evaluated the same way as the other research institutions.

This answer might have repercussions on how to understand a subset of non-university research institutions that are not developers, but almost purely users of knowledge. It might be that, just as is the case for non-university institute G, this subset of institutions only is innovative on the level of incremental innovations, when knowledge is transformed for purposes of problem solving not related to scientific activities. If this is the case, the question could be raised, if these institutions should be seen as scientific research institutions in the narrow sense at all or if they are closer to

a form of knowledge intensive service institution. In the case of institute G this seems to be the an integral part of the self-reflection of the two interview partners.

5. Descriptions of the Analyzed Companies

7.1. Company A:

The large company is the Austrian subsidiary of a telecommunications multinational. The firm has been founded in the 1920s and originally had specialized in the during this time booming market of electrical products. Soon the first product lines for the telecommunications sector were in operation. However, the company only in the 1970s focused its production on telecommunication products.

Over time a cooperation between the company and a foreign multinational had grown, which finally gave way to a friendly takeover of the Austrian firm. The subsequent changes led to a restructuring of the Austrian firm. The local product line was limited to a handful of goods, while a number of products was transferred to the foreign mother company. Since the takeover research and development (R&D) expenditures stagnate. The R&D performed in Austria consists more and more of incremental innovations. Nowadays, not only is the 'R" of 'R&D" non-existent in the daily work of the 'R&D" departments, but even development seems to occur only rarely. The overwhelming part of the R&D department's work consists of experimental development (E). The primary reason for D&E is to raise the functional product performance.[12] Patent activity is low.

Interconnectivity is low, too. Most interactions in the realm of R&D happen inside the company network. Furthermore, at least 60 % of D&E are carried out by single researchers - a rather high figure given the nature of telecommunications and the

[12] As reasons for innovative behavior three closed and one open category each for product and process innovations were given. The closed categories are taken from Abernathy/Utterback 1988, p.26. Specifically, for product innovations these categories are raising the functional product performance, enlarging the product variety and cost reduction. For process innovations the categories were cost reduction and raising the quality of the products.

complexity of the topic. All Internet services are freely available to the R&D personnel.

Organizational innovativeness in the area of R&D is low. A change in the structure of rooms of the company has led to a decrease in interconnectivity. However, the problem seems not have been addressed by management. In general, management seems to be more often reactive than active in decision-making.

Consequently, one of the barriers to innovation given by the interview partners was slowness of management decisions. More importantly, the only barrier named by both interview partners was the hierarchical structure of the company, which was perceived as deadly especially for innovativeness in the R&D sphere. A direct result of the firm's hierarchy was a skewed communication structure, hampering the information flow and hindering the creativity of the personnel.

7.2. Company B:

The large company is centered around the transport business. It has a long history, with predeceasing organizations existing already during the last century. During the last decade a considerable modernization push has been transforming the company into a more modern entity. Recent changes in the structures of laws affecting transportation have led to a furthering of the restructuring process.

Two in many respects widely differing departments in the realms of R&D have been analyzed. Department 1 is innovative in practically all respects. Its main responsibility is the development of standards for the company as well as the improvement of a specific part of the firm's infrastructure. R, D and E are performed by the department. However, the larger parts of all three, R, D and E, are not carried out by the small department itself, but are either outsourced to companies with long-standing relations to the firm or are done in-house. The two interview partners in this department suggested that most of R, D and E nowadays is performed in the form of

projects - which is different an approach from the situation in the firm only a decade ago, when R&D was performed in a more traditionalist way.

Reorganizations have not only shaped the way work is carried out, but also the very structure of the company. Department 1 exists as an own entity only since mid-1995. However, the personnel has been working together for a somewhat longer time. Therefore, long-running projects have been cared for by the same persons for years. Product innovations are primarily developed for cost reduction purposes, with both prototypes and patents every now and then coming into existence. Process innovations are the daily work of the department and are being steadily produced. During the last decade this kind of innovation increasingly has become an instrument of the company to maximize cost reduction under the constraint of acceptable risk structures.

Interconnectivity of the department is paramount for the work of the small unit. Long-standing connections are to be found with in-house units, national and international companies as well as research organizations. Internet usage is high and without restrictions possible for all personnel. Leadership is active.

Department 2 has, despite similarities in the task structure, a different innovation behavior. To begin with, the department is larger. It has not been affected by the restructuring processes of the company. Nevertheless R&D is outsourced, so that only incremental innovations are connected with the daily work. Product innovations are done to raise functional product performance as well as to slash costs. Patents and prototypes created by R&D are taken out by the companies doing the R&D for department 2. Both persons available in the department did have no definite knowledge about the partner companies' patent activity. This is all the more surprising as the partner companies have a history of long-standing contacts with the department - and therefore should be well known to the department.

Interconnectivity in general seems to be low for department 2. There is only one computer in the whole department connected to the Internet.

Regarding barriers to innovation surprisingly little information was provided by the three interview partners. One person gave as barrier management's slow decision making processes, another person a dearth for capital, which would be necessary for long-term R&D decisions.

7.3. Company C

The large company is part of the Austrian banking sector. The organization has been founded in the 1920s. With the opening of the national economy during the 1970s the bank internationalized its operations increasingly. As is true for most large universal banking institutions in Austria, the organization enlarged its foreign operations during the 1980s further by opening branch offices in a number of countries. Foreign operations went on to grow during the 1990s, leading to a number of cooperations with, mostly larger, foreign banks.

Two departments have been analyzed. Department 1 has as its task to perform a large part of the international activities of the organization. The business unit was restructured and enlarged a year ago. For the department "R&D" is a scattered business, recognized as necessary, but not of primary importance. Moreover, "R&D" for the department actually consists of experimental development, fitting the needs of the unit's operations. The department's innovativeness is ambiguous.

Innovations in general seem to be generated by the department as a reaction to the wishes of customers and from the analyses of foreign and domestic competitors. Product innovations were made both out of a drive to diversify products and to raise functional product performance. Process innovations in a number of cases were generated by another department, specialized in operations research. The main reason for this type of innovation was the reduction of costs, regularly achieved through quality control measurements as ISO 9000 procedures.

Interconnectivity in department 1 was high with respect to international contacts. However, it seemed to be somewhat lower with respect to in-house contacts. This could be partially explained by the specific international orientation of the department. Internet usage was restricted.

Department 2 has as its primary tasks organizational planning, analyses and advisory functions. It recently was restructured. It has lived through a process of growth, beginning in the late 1980s. The department has a high level of innovativeness. "R&D" consists of research, development and experimental development, which all are frequent processes. However, research regularly is outsourced - often to a company belonging to the bank.

Innovations of all types are prominent. Some innovations are radical in nature, having been described by the interview partner as new in respect to European, some even for global markets. Due to the nature of innovations a distinction between process and product innovations was not sensible. Interconnectivity in department 2 generally was high. No Internet restrictions were applied to the personnel.

Both departments were oriented towards foreign markets, both had active headpersons. As barriers to innovation low qualification of personnel was given, as well as a lack of capital. The latter factor at first sight seems a bit peculiar for a bank, but was explained by both interview partners with the small marginal returns to investments in the tight Austrian banking sector.

7.4. Company D:

The small company is specialized in the production of plastic parts. It started as a family business in the 1920s producing sophisticated metal parts under a craft-oriented production regime. Production and size of the company expanded over time, to be reduced later on. The company still is a family business and craft-oriented. It now concentrates on the small-scale production of specialized plastic parts.

Product innovation is a frequent process. It is pursued primarily for the extension of product lines, but also to raise functional product performance. Patents are infrequently arising out of this activity. The personnel has to deal with process innovation daily, mostly in search for better production techniques and materials. Process innovation is done for purposes of cost reduction as well as to raise the quality of the final products.

National as well as international projects are a product of long-standing relationships with customers and suppliers. In addition, personal contacts of the headperson resulting from an employment for an Austrian multinational company are leading to new contracts. Although the company does some work on an international level, most of its partners are Austrian.

The "R&D" work at the company consists primarily of experimental development. Interconnectivity of the firm is high, a necessity of the changing market niches the company has to cope with. Leadership is active. No computer of the company is connected to the Internet - a fact to be changed in the near future, according to the interview partner.

7.5. Company E:

The small company is specializing in an ecological market niche, in-between construction, gardening and landscaping. The firm was founded as an academic work group in the mid 1980s. It originally was centered around the production of a single good. Since then, the product, which has proven to be highly successful, has been developed into a fully grown product line. In addition, a second product line is being licensed from a foreign company and is slowly being expanded.

The company is innovative, despite being specialized in a business sector traditionally slow in the uptake of new ideas. Product innovations have as their primary goal to raise the functional product performance. Process innovations are only of

secondary importance and happen infrequently. Patents can not be taken out, due to the nature of the products and processes. However, know-how is licensed to a number of foreign companies in neighboring countries, with interest awakening all over Europe at the moment.

Although the products of the company from begin on have been comparatively knowledge intensive, professional R&D activities have been started only recently with a number of projects. Until a few years ago, the product line was developed through tinkering around with construction techniques and materials. As the company currently is the market leader for these specific product-lines in Austria, its strategy is to stay ahead of the followers and diversify into technologically more sophisticated directions. To this end, R&D now is actively pursued. Experimental development has been part of the company's work for a somewhat longer time.

The interconnectivity of the company is high. There are not only contacts with a number of universities, but also with the local chamber of commerce, which has proven to be useful in information gathering and the structuring of contacts. Contacts with other companies and customers are actively pursued nationally as well as internationally. The firm has no Internet connection, due to its location in the countryside, where the Internet has not been available until now. Leadership is active.

As barriers to innovation the interviewed person has given a dearth for information about technologies and the market as well. Here the lack of information on the possibilities for EU R&D funding information in the specific specialization of the company was stated. Other barriers are the low level of innovativeness of the personnel and the lack of capital.

6. Analysis of the Companies

Analogous to the warning at the beginning of the data analysis for the research institutions, it should be emphasized here that, due to the small sample size, the results of this analysis can be seen as indicators pointing at a possible correlation between certain factors. They can not be seen as a proof for such correlations.

During the research phase of the project it became clear that the sheer size of some of the large companies would lead to a problem. In the original Austrian Survey for Institutions and Transfers (ASIT) the interviewed persons had time to go through the questions, which were presented in advance, and could ask personnel from other departments about specific data. In the subsequent personal interviews leading to this paper, the task was to interview persons alone, to learn about their specific opinions on a variety of innovation related subjects. Due to a constraint in manpower, the choice was either to make two or three interviews in one department, running the risk of missing the 'big picture", i.e. not learning about the innovation activities of the firm, but only of one isolated department, or to interview personnel from two departments and risking not to have a that detailed knowledge about the operations of each unit. Finally, the second strategy was chosen in the hope to get a more comprehensive picture of the whole company.

However, the decision came at a price. In both cases, in which such a strategy was chosen, the two analyzed departments turned out to be not only different in size, task and structure, but also with respect to their innovativeness. Consequently, they have to be described and analyzed separately. This decision was formalized by assigning the numbers 1 and 2 for the respective departments of each of the two companies.

Table 5 shows these changes and adds IDs to the list of companies that have been described previously and are to be analyzed in this section.

Table 5. Final Sample of Companies

ID	Number of Depts. Analyzed	Innovativeness	Sector	Size
A	1	Innovative	Telecommunications	Large
B	2	Non-innovative	Transport	Large
C	2	Non-innovative	Banking	Large
D	1	Innovative	Plastics	Small
E	1	Innovative	Gardening	Small

Table 6 is an attempted systematization of the analyses of the companies.

Table 6. Comparison of Companies

ID	A	B		C		D	E
		Dept. 1	Dept. 2	Dept. 1	Dept. 2		
Innovations: Output	-	+	-	+/-	+	+	+
Output Classification	E	R, D, E	E	E	R, D, E	E	R, D, E
Innovations: Organization	-	+	-	+/-	+	n.m.	n.m.
Innovations: Internet Usage	+	+	-	+/-	+	-	-
Leadership	passive	active	passive	active	active	active	active
Interconnectivity	low	high	low	ambiv.	high	high	high
Foreign Markets	yes	yes	no	yes	yes	ambiv.	yes

Note: "n.m." stands for "not measured".

If analyzed by department, the results of the analysis show, as was intended, two extreme groups, one innovative, the other not. Only one institution - department 1 of company C - is ambivalent in more than one of the aggregated categories.

The category "output innovations" is an aggregate of both product and process innovations. They were put together as it turned out that the nature of product and process innovations in most cases was too product specific to be evaluated standing alone.[13] The "output classification" is done along the standard categories of basic research (R), applied science or development (D) and experimental development (E).[14] The category "organizational innovation" is an interpretation of interview partner's characterizations of the number of changes in structure and process of the company unit. This category has not been used for the two small firms, as they were too small to make organizational changes clearly measurable with the data available. The category "Internet usage" has been introduced in order to measure the number of computers connected to the Internet per personnel and the restrictions in the usage allowed for each person, being one indicator for innovative usage of new technologies. The Internet is not only of growing importance for the commercial development of a number of sectors, but is also an indicator for the interconnectivity of an organization.[15] "Leadership" is a rather soft category with a self-explanatory name. When it became clear that the management style of the person at the head of the company had a larger than expected influence on the personal as well institution's innovativeness, the category "leadership" was added also for the companies. "Interconnectivity" is an aggregate of the number and nature of contacts internally as well as with other companies and research institutions, domestic and foreign. The category "foreign markets" signifies the efforts of the company unit to orient itself on foreign competitors as well as their tries to set foot on foreign markets.

[13] That might seem to be a surprising argument. However, one should not forget that in the sample companies from the service sector were included. This influences the concepts of innovativeness considerably, creating the need for a wide variety of different products and processes to be evaluated.

[14] The respective activities were assigned to companies not only according to the R&D performed in-house, but also according to the outsourced R&D activities, as long as these activities were closely watched. The criterion for "closely" was the number of interactions with the partner organization and the presence of a learning process - i.e. if the impression was that a learning process had as its primary reason the outsourced R&D activities - then the outsourced R&D was not distinguished from in-house activities.

[15] More on the importance of the Internet for this analyses in the last section.

Although the categories are not as clearly dichotomous as in the case of the research institutions, a distinct picture emerges from the aggregated data. With the exception of one rather ambiguous case, output innovations, organizational innovations, leadership and interconnectivity form two ideal typical groups, which indicate a positive correlation of these categories. Analogous to the research institutions the connection between innovativeness and leadership seemed to be especially strong. Again, active headpersons seemed to influence innovativeness positively. Furthermore, signs of high interconnectivity seemed to come together with innovativeness.

"Output classification" shows, with the exception of company D, an interesting profile. The innovative company units all are engaged not only into experimental development, but into research and development, too. They integrate all these in their innovation processes. In contrast, the non-innovative units all were limited to experimental development. The one exception to this, company D, is an organization most likely below the critical mass of personnel making a firm capable of engaging into research and development: company D's personnel size was in the one digit range.

The category "output classification", one should recall, does not address the question if R&D is mostly performed in-house or outsourced. In fact, this variable did not seem to have an effect on innovativeness at all. Nevertheless, the category "output classification" attempts to measure the learning processes in the company unit with respect to R&D in a crude manner. Drawn from the description of projects, the degree of how closely followed outsourced R&D was by the evaluated business unit, should help to evaluate the efforts of the personnel of the analyzed unit to be involved in the actual R&D process. Another indicator was the degree of interlinkages with the organization actually carrying out the R&D - regardless if this were in-house or outsourced activities. The results of the analyses seem to suggest that a positive correlation between learning through closely followed or self-performed R&D activities and innovativeness exists.

The category "organizational innovation" was measured only in the large firms. If one excludes the small firms and the ambiguous case from the sample, only four cases are left for comparative purposes - a sample a bit meager for indications of correlations. Nevertheless, in the four remaining cases innovativeness and organizational change go hand in hand.

In contrast to the research institutions, Internet usage seems not to correlate with innovativeness. A possible bias could be suspected to originate from the two small firms, which both wanted to get Internet connections, but did not have them yet. However, Internet usage did not seem to be correlated with innovativeness for both, small and large, companies. This is interesting, as for the research institutions such a correlation seemed to exist. One might conclude that the medium Internet at the moment is better suited for the needs of researchers than for business. In fact, one of the two rationales for the costly introduction of the Internet's predecessors was to aid basic research.

Similarly, the category "foreign markets" seems not to be connected with any form of innovativeness. This is a bit surprising, given the common wisdom suggesting the existence of lean and flexible institutions oriented to the international market place.

Another category seemingly without correlation to innovativeness is the existence of a training program. However, it should be kept in mind that, due to time constraints, not the programs itself were evaluated. It might be questionable if badly designed training programs make personnel or whole organizations more innovative.

As has been pointed out, one company department has been evaluated as ambiguous in a number of categories. The case is perhaps explainable by the transitory nature of the department. It was restructured during the last year. As a consequence, the tasks of the business unit have changed considerably. In addition, the headperson was exchanged a year before. Given all these developments still causing new situations and processes, it might be that not enough data were available for a closer evaluation of the department.

In respect to the perceived barriers to innovation, three reasons were provided more often than twice. The number one barrier, given four times, was the lack of capital as a backup for decision-making processes, which at times carry great risk in the sphere of R&D. The number two barrier was personnel. Three interview partners have given three clues for how they would like to change personnel: More risk taking behavior, more willingness to learn and more willingness to be innovative. A second "number two", ex aequo with personnel, was the leadership of the companies, which was two times qualified as too slowly reacting to market changes and once not willing to sustain R&D.

7. Innovativeness and the Production of Knowledge

Box 1. The New Production of Knowledge

"Science" is, in contrast to the way the term is used in everyday life, not only the way of obtaining knowledge in a specifiable and reproducible manner, but also a system of believes in a specific set of traditions. These traditions include the ways in which problems are selected and specified, how the persons tackling these problems are chosen and how their work is going to be judged. The classical form of knowledge production in a well defined system grouped around universities and academies, so the thesis of a recently published book, is increasingly substituted by other ways. One indication for these changes is the proliferation of new institutions of knowledge formation, as consultancies, think tanks and other flexible forms of organization.

In the 'New Production of Knowledge" Gibbons et al describe recent changes in the form of knowledge generation. These are, amongst others, signified by:

- a) the increased production of knowledge in the context of application,
- b) a growing transdisciplinarity of knowledge generation,
- c) the proliferation of heterogeneous groups of researchers,
- d) an enhanced societal control over the production of knowledge,
- e) a broader base of quality control for new knowledge, and
- f) more interlinkages between research groups.

The increasing application context of knowledge formation destroys the artificial boundaries between basic and applied science. The growing transdisciplinarity has effects on how we conceptualize knowledge producing institutions, first of all universities, but also classical non-university research institutions. Finally, financing as well as governing of research shall be influenced by the proliferation of heterogeneous groups of researchers, manifesting itself in the constant birth, extinction and rebirth of groups with problem-centered missions, flatter hierarchies, denser networking qualities and transdisciplinary composition and visions. Especially this last characteristic of the new production of knowledge depends heavily on a functioning telecommunication network as well on the drive of a society to internationalize. The denser the international networks are woven, the more efficient the knowledge production and with it the national innovation system is likely to be.

In table 7 an attempt is made to confront the analyzed research institutions with the new mode of knowledge production as it was described further above.

Table 7. The New Mode of Knowledge Production and the Analyzed Research Institutions

Characteristics of the New Mode of Knowledge Production	Austrian Research Institutions		Verification
	Innovative	Non-Innovative	
Increased Production of Knowledge in the Context of Application	D, E, F	A, B	True
		C	Not True
Growing Transdisciplinarity of Knowledge Generation	D, E, F		True
		A, B, C	Not True
Proliferation of Heterogeneous Groups of Researchers	D, E, F		True
		A, B, C	Not True
Enhanced Societal Control over the Production of Knowledge	F	A, B, C	True
	D, E		Not True
Broader Base of Quality Control for New Knowledge	D, E, F		True
		A, B, C	Not True
More Interlinkages between Research Groups	D, E, F		True
		A, B, C	Not True

Note: The ambivalent non-university research institution G was excluded from the analysis.

The results of the analysis indicate that for almost all variables innovativeness and the characteristics of the new mode of knowledge production are positively correlated. The only exception is the category "enhanced social control", which, however, is not likely to have a direct impact on innovativeness.

The results also show that for many variables non-innovativeness and sticking to the old mode of knowledge production are positively correlated. Two exceptions are the category "application context" and, again, the category "enhanced social control". The first case might be an indication that even for less innovative institutions the creation of knowledge in the context of application is becoming a standard feature. The second case is another indication that this specific category has no direct influence on innovativeness.

The exercise working so well for research institutions is not functioning for companies. Most companies seem to be running under the new mode of knowledge production, so that no indications for clear cut correlations could be found. A working hypothesis for an explanation could be that companies had to work under the new mode since a prolonged period of time, so that in this sphere the new mode of knowledge production is "normality" already.

Therefore, instead of a confrontation of the data with the characteristics of the new mode of knowledge production, a comparison with a classic list of factors influencing innovativeness positively is attempted in table 8.

Table 8. Comparison of Data with Christopher Freeman's Characteristics of Successful Innovating Firms

Freeman's Characteristics	Own Data
1. Strong In-house Professional R&D	No Indications for Correlation
2. Performance of Basic Research or Close Connections to Those Performing Research	Yes, Strong Indications for Correlation
3. Use of Patents	Yes, Some Indications for Correlation
4. Large Enough Size to Finance R&D Over Extended Periods of Time	No Indications for Correlation
5. Shorter Lead Times Than Competitors	Not Measured
6. Readiness to Take Risks	Yes, Some Indications for Correlation
7. Early Identification of Markets	Yes, Some Indications for Correlation
8. Efforts to Involve, Educate and Assist Users	Yes, Some Indications for Correlation
9. Coordination of R&D, Production and Marketing	Not Measured
10. Interlinkages to Scientific World and Customers	Yes, Strong Indications for Correlation

Source: Freeman 1982, p. 112; Own Data

Of the eight characteristics proposed by Freeman that actually were measured, six were positive and only two negative. The negative values for the categories number one and four might result from the decision to include service sector companies, which are not included in Freeman's work.

From all what has been said one can conclude that the process of adjustment of the Austrian innovation system to needs emerging from a variety of often global trends is reflected in the changes of research institutions and companies as well. Both groups of organizations follow the international trend towards a new form of knowledge production that is going to change our conception of how knowledge is created, disseminated and used. Some of the analyzed institutions are further in this process of change than others.

One central concern for policy formulation following from this is the decision if it is better to induce the slower changing institutions to develop faster or to foster the faster changing ones to become true centers of excellency ready to compete in the international marketplace. Models for both types of developments are existing. Whereas France or the USA are examples for national innovation systems with a broad base and a small, but highly developed, top, Germany and Austria are examples for national innovation systems featuring both a broader base and a larger number of institutions which are well developed, but not necessarily comparable to French or US high end organizations. Put in cruder terms: while there do exist no Harvards, MITs or Grande Ecoles in Austria or Germany, there are no small community colleges of poor states as Arkansas or Idaho either.

Furthermore, the question has to be posed if all knowledge producing institutions are to run under the same mode of knowledge production. For example, does it make sense for a national economy to induce *all* "fundamental" science to produce knowledge under the constraint of application centeredness ? What effects would that have on the long term goals of development of science and technology ? Most likely Austria would encounter positive short term, but negative long term effects. It is possible that innovations, which are "on the shelves" of research institutions, could enter the market place sooner, if policy measures to that end would be enforced. However, if the science base of a country is not built and tendered, it might well happen that the national economy of the same country would feel this in numerous imaginable ways, from badly educated researchers and engineers, who are not acquainted to "best practices" to losses in the diffusion of technologies, who

simply get lost or are never introduced, if a skill base is not readily available in certain fields.

Another, similar, policy issue is if we do want *all* "soft" sciences as the humanities and social sciences to run under the same mode of knowledge production as for example the technical sciences ? What effects would that have on the ability of the soft sciences to analyze and criticize societal developments and make proposals for corrections of these developments ? In a time when quality control and evaluation mechanisms are introduced into all walks of life, when the creation of new knowledge is accelerating so that most information acquired at school is meaningless fifteen or twenty years later, it is the role of humanities and social sciences to serve as a quality control and evaluation mechanism for the whole society. Critical humanists and social scientists have to find conditions so to be able to work in the interest of society, but they also have to be in a position where they can be criticized by society for acquired, but out-of-date privileges as for example life-long tenure.

Obviously, there are no easy answers to the above posed questions. However, one should keep in mind that the answers to these questions are likely to have detrimental long-term effects on the Austrian society. The changes under way in the spheres of Austrian science and technology therefore should not only be considered carefully, but also managed in a way so that the different societal interests are included in the policy making process. Then the success of the implemented policy measures are much more likely to lead to policy outcomes accepted by a large majority of the involved constituencies and a more competitive national economy.

8. References

Books:

Abernathy, W./Utterback, J., 'Patterns of Industrial Innovation", in: Tushman/Moore, Readings in the Management of Innovation, Cambridge, Massachusetts: Ballinger, 1988

Freeman, C., The Economics of Industrial Innovation, 2nd ed, Cambridge, Massachusetts: MIT Press, 1982

Freeman, C., Technology Policy and Economic Performance: Lessons From Japan, Pinter, London, 1987

Gibbons, M. et al, The New Production of Knowledge, London: Sage, 1994

Hughes, T., Networks of Power, Baltimore: Johns Hopkins, 1983

Lundvall, B.A., 'Innovation as an Interactive Process: From User-Producer Interaction to the National System of Innovation", in: Dosi, G. et al (ed), Technical Change and Economic Theory, London: Pinter, 1988

Lundvall (ed), B.A, National Systems of Innovation, London: Pinter, 1992

Nelson, R. (ed), National Innovation Systems, Oxford:UP, 1993

Porter, M., The Competitive Advantage of Nations, London: Macmillan, 1990

Articles and Documents:

Braun, T. et al, "World Sciences in the Eighties: National Performances in Publication Output and Citation Impact, 1985-89 versus 1980-1984, Part II. Life Sciences, Engineering, and Mathematics", in: Scientometrics, Vol 31, 1(1994), pp.3-30

Braun, T. et al, "World Science in the Eighties: National Performances in Publication Output and Citation Impact, 1985-89 versus 1980-1984, Part I, All Science Fields Combined, Physics, and Chemistry", in: Scientometrics, Vol 29, 3(1994), pp. 299-334

David, P./Foray, D., "Accessing and Expanding the Science and Technology Knowledge Base", OECD, DSTI/STP/TIP (94) 4

Müller, Karl (ed), "The Austrian Innovation System", Parts I-VI, Project Report, Institute for Advanced Studies, 9/1996

Smith, K., "Interactions in Knowledge Systems", OECD, DSTI/STP/TIP (94)15

Sporn, B., "Adaptive University Structures", paper given at the Annual Conference of the Association for the Study of Higher Education, Orlando, Florida, USA, 11/1995

Internet:

"Biochemische Forschung nicht konkurrenzfähig", in: APA-Net Science Week, http://www.apa.co.at/scripts/depot/swe, 12-11-1995

Appendix

A1. List of Questions for the Personnel of Research Institutions

Leitfaden für Interviews Forschungsinstitutionen/OECD-NIS

A. Charakterisierung Institut:

1. Hauptarbeitsbereiche

2. -a Zahl der Mitarbeiter

   -b Qualifizierung des wissenschaftlichen Personals

   -c Weiterbildung

   -d Migration

3. Budget/Budgetveränderungen:

-a Prozent Finanzierung Rechtsträger:	en bloc
	via Aufträge
-b Prozent Finanzierung sonstige (welche ?):	en bloc
	via Aufträge
-c EU:	Anträge abgesendet
	bewilligt

   Veränderungen Situation vor allem seit EWR/EU-Beitritten

4. (A1) Organisation:

   -a Alter der Institution

   -b Organisationsform

   -c Änderungen in der Organisation/Gründe

5. Ausstattung:

   -a Telkomm

   -b Computer

   -c Geräte/Lehrmittel

B. Output:

1. (B1,3,4) Forschung:

    -a Methoden

    -b Theorien

    -c Themen neu erschlossen

2. (B2,3,4) Publikationen (working papers, Artikel, Bücher, eigene Reihe)

3. (B2,3,4) Projekte der letzten Zeit

4. (B2,3,4) Prototypen, Patente, etc.

5. (B2,3,4) Studentenzahlen, Anfänger/Absolventen Ratio

6. (B6,3,4) Lehre:

    -a Methoden

    -b Theorien

    -c Themen

    -d Unterrichtsformen neu erschlossen

    -e Ausweitung der Lehre: Zielgruppen (Erwachsenenbildung, Zielpublikum gen.)

C. Beschreibung eines typischen Projektes aus der jüngeren Vergangenheit

D. Arbeitszeitaufteilung:

jeweils Einschätzung eigene Arbeitszeit und die der Mitarbeiter

1. Bürokratie

2. Studenten

3. PR

4. Forschung:
    - 1 Ratio R - D - E
    - 2 einzeln
    - 3 mit Mitarbeitern des Institutes
    - 4 Kooperationen im Forschungssystem
    - 5 Kooperationen außerhalb des Forschungssystems

5. sonstige (technisches Service, Selbststudium etc.)

E. Außenbeziehungen professionell:

(Inhalte, Rankings, Häufigkeit, Personenzentriertheit)

1. (E1) Informeller Informationsaustausch (Fachinfos, Arbeitsplätze, Projekte...)

2. (E1) Formelle Präsentationen der eigenen Arbeit/der Institutsarbeit (Konferenzen, Medien...)

3. (E1) Publikationen jeglicher Art

4. (E1) Arbeitskooperationen (Projekte)

5. (E1) Dienstleistungen (Konsultationen...)

F. Unter welchen Bedingungen könnte das Institut innovativer sein

1. (F1) Personal

2. (F1) Geld

3. (F1) Geräte

4. (F1) Organisation

5. (F1) Kooperationsbereitschaft

6. (F1) Lehre

A2. List of Questions for the Personnel of Companies

Leitfaden für Interviews Betriebe/OECD-NIS

A. Charakterisierung Betrieb:

1. -a Wirtschaftsbranche/Hauptarbeitsbereiche Betrieb

   -b Hauptarbeitsbereich F&E Abteilung oder Äquivalent, Stellung Abt. in Firma

   -c Primäre Aufgaben Person

2. Situation Unternehmung (Marktstellung, Entwicklung von Umsatz/Gewinn/ Investitionen/Investitionen in F&E)

3. -a Zahl der Mitarbeiter/der F&E Abteilung

   -b Qualifizierung des (wissenschaftlichen) Personals

   -c Weiterbildung

   -d Migration

4. Organisation:

   -a Alter der Institution

   -b Organisationsform

   -c Änderungen in der Organisation/Gründe

5. Ausstattung F&E Abt.:

   -a Telkomm

   -b Computer

   -c Techn. Geräte

B. Output:

1. Produktinnovationen:

   -a Zwecks Erhöhung der funktionalen Produktperformance, Produktverbesserung

   -b Zwecks Ausweitung der Produktpalette

   -c Zwecks Kostenreduktion

   -d Entstehung von Prototypen, Patenten

2. Prozess/Verfahrensinnovationen

-a Zwecks Kostenreduktion

-b Zwecks Verbesserung der Qualität der Produkte

-c Entstehung von Patenten

3. F&E - Projekte der letzten Zeit (Publikationen?)

C. Beschreibung eines typischen Projektes aus der jüngeren Vergangenheit (Evaluation?)

D. Arbeitszeitaufteilung (Einschätzung eigene Arbeitszeit):

1. Operativer Bereich:

-a Kundenkontakte/"PR"

-b Aufträge

-c After Sales

-d Administration

-e Sonstiges

2. Forschung: - a Ratio R - D - E

- b einzeln

- c mit Mitarbeitern des Institutes

- d Kooperationen im Forschungssystem

- e Kooperationen außerhalb des Forschungssystems

3. Sonstige

E. Außenbeziehungen professionell (Inhalte, Rankings, Häufigkeit, Personenzentriertheit):

1. Informeller Informationsaustausch (Fachinfos, Projekte, Schwarzes Brett...)
2. Formelle Präsentationen der eigenen Arbeit/der Unternehmung (Konferenzen, Presseaussendungen, Medien...)
3. Publikationen jeglicher Art
4. Arbeitskooperationen (Projekte)

F. Unter welchen Bedingungen könnte der Betrieb innovativer sein:

1. Personal
2. Eigen-/Fremdkapital
3. Rahmenbedingungen Standort
4. Kosten
5. Organisation
6. Informationen (Markt, Technologie)
7. Kooperationsbereitschaft (intern, extern)
8. Unternehmensführung

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