TECHNOLOGY TRANSFER AND UNIVERSITY-INDUSTRY RELATIONS. INSTITUTIONAL, NATIONAL AND EUROPEAN POLICIES AND STRATEGIES.

Manfred Horvat

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University-industry collaboration and technology diffusion are complex social communication processes across the boundaries of different systems with different objectives and rationalities. Symplifying interpretations, concepts and approaches will *not lead to success in terms of industrial innovation and competitivity but will lead to failure and thus widen the gap between the industrial and the academic world. Technology transfer is interpreted as a complete process of innovation and technology diffusion*

La colaboración universidad-industria y la difusión tecnológica son procesos de comunicación sociales complejos a través de los límites de diversos sistemas con objetivos y racionalidades diferentes. Simplificar interpretaciones, conceptos y enfoques no conducirá al éxito en términos de innovación y competitividad industriales sino que llevará al fracaso y, por tanto, a ensanchar la brecha entre el mundo académico e industrial. Se interpreta la transferencia de tecnología coma un complejo proceso de innovación y difusión tecnológica

Unibertsitatearen eta industriaren arteko lankidetza eta teknologiaren hedapena komunikazio prozesu sozial konplexuak dira, helburu eta razionalitate desberdinak dituzten hainbat sistemen mugen bidez. Interpretazioak, kontzeptuak eta ikusmoldeak sinpletzeak ez du, industria berrikuntza eta lehiakortasunan dagokionez, arrakasta ekarriko, porrota baizik, eta, horrenbestez akademia eta industria munduen arteko leizea zabaldu besterik ez du egingo. Berrikuntza eta hedapen teknologikoari doakionez, teknologiaren transferentzia prozesu konplexutzat hartzen da.

1. Introduction

In the discussion on technology transfer a traditional model of innovation plays still an important role. Following this model, technology development or the innovation process respectively are interpreted as a sequence of separated elements - invention, research, development, design, prototype, product testing, market research, manufacture, marketin, exporting - with different actors responsible for each phase of the process. At best, this can be compared to a relay race. However, there is no guarantee of a smooth handing-over from one actor to the next..

Innovation is embedded in an economic, legal and social environment and context formed by aspects such as government policies and programmes, the role of the social partners, funding and procurement programmes, the legal framework, the banking systems, the education and research system responsible for the knowledge base, the university and the industrial culture regarding collaboration.

More recent attempts (see e.g. L. SOETE and A. ARUNDEL 1993) describe the innovation process are based on a systems approach that stresses the interactive character of technology development. There is not one single actor - be it individual or institutional - responsible for shaping technology, but the creation of new technologies is based on direct and indirect interaction of many actors individuals and organisations: industry and academia, government and the social partners, funding organisations, scientific and professional organisations, and - last but not least - public opinion, value judgements and declared and hidden interests. Following this model, technology development is characterized by multidirectional linkages - both between the various actors and the different elements of the process, which are very often identical or overlapping, and often cannot be seen separated at all - as well as feedback loops and parallel processing.

In general, every individual innovation has its specific, often unique, characteristics. Therefore, supportive measure should concentrate on creating a supportive environment for innovation.

2. University-industry collaboration: Models, problems and support models, basic requirements and some conclusions

2.1 Different forms of university-industry collaboration

Dealing with university-industry relations one has to bear in mind that there is a complex pattern of different interaction processes between the two worlds or rather the two areas of the

innovation system. Education as well as research (curiosity driven and mission oriented research), consultancy and services exhibit forms of communication, where each has its specific roles and functions. In addition, one has to distinguish between the individual, the group, the departmental, the cross-departmental and the institutional level.

The prevailing form of university-industry interaction is education undergraduate and postgraduate education. In that area, increasingly continuing education, lifelong education is becoming an important field of university activities, following the fast development of knowledge creation and, as a consequence, the fact, that education and organized learning cannot be restricted to a limited period in life. University education is characterized by the notion of the combination between research and education. The researcher teacher not only passes on knowledge but also attitudes, values and basic principles of intellectual activity. The graduates are the main “carriers” of new knowledge, of innovative methodologies and creative capabilities and skills.

Continuing education is a new instrument for the dissemination of new research results, thus becoming a momentuous part of the innovation process, supporting the impelementation of new technologies by developing the qualifications and competences of the personnel, thus paving the way for the adoption, adaption and the implementation of new technologies. Continuing education is becoming an important facet of technology transfer, and provides - besides its primary objectives - important opportunities for university-industry communication, feedback and technology transfer.

Curiosity driven, “free” research is one of the most important driving forces and sources of innovation. The traditional form of dissemination is publication in learned jounrnals and presentation on expert conferences. There is, however, increasing concern that there is a “missing link” between this area of research, the development of new industrial processes and viable products, and, finally, the market. Many research results with innovative potential stay withing the scientific community. It takes, at least, a long time from the creation to a possible area of application. For many results the opportunity of application is missed at all. In accordance with the traditional career paths of academia, with the publication of his findigns the researcher looses the interest in his “product”. Economic exploitation is not seen as a rewarding activity, and, in addition, the researchers don’t have the necessary competences. Screening of research results for industrial applicability and exploitation, marketing as well as dissemination and technology transfer programmes as well as appropriate patenting and licencing services are thus important areas for possible institutional strategies, programmes and activities. Interactive and collaborative models, where academics and industrial experts are working together could ensure more succeful transfer results than traditional approaches.

Direct links with industry are estabished in the framework of contract research, consultancy and services. There, in most cases the problem is defined by industry and a university member, a group or department is offering its capacity for the solution. Very often, this approach is limited to short term ad hoc problems and is not linked with long term innovation strategies of companies. This is especially true for small and medium sized enterprises (SMEs), who, in addition, are facing the problem of finding the right partner at the university, which is seen as a large complex and intransparent Organisation. Large companies, with academic staff and even a research department, can arrive at an appropriate division of labour in the R&D area, even on a long term perspective based on a well designed technology strategy. For SMEs, however, very often, problem analysis, identification of technology opportunities,

organisational requirements and skills development needs for implementing new technologies, appropriate funding and financing models present difficulties which they cannot solve themselves. Thus, for university-SMEs collaboration more complex integrated models of technology transfer have to be developed and applied, following the specific needs of the respective target group or firm.

There are other forms of persons oriented/human centred exchange mechanisms: staff exchange, university-industry secondments, (part-time) industrial chairs, just to name some specific approaches that are, in many cases, limited to the solution of a specific problem or to a well defined proyect. The British Teaching Company Scheme, the EU COMETT placements, the EU Human Captital and Mobility Programme, the German personnel transfer models are examples of dixerent attempsts to the same process.

The setting up of new technology oriented companies as spin offs from the university is the nest form of university-industry interaction. A researcher leaves the university with an innovative idea and starts a new enterprise to exploit his research findigns on his own. In this case, the researcher changes from the academic system to the industrial system. It is, of course, only natural that these persons, due to their origin, in many cases keep n close contact and establish long term collaborative connections with their university. Incubator centres, science parks, technology centres are different models to support the start up of new companies with a university background. These centres offer infrastructural support and managerial support. Very often, on a closer look, the main offer is cheaper, sometimes publicly sponsored, office and laboratory space, with flexible possibilities for expansion. Central support like secretarial services, printing and copying facilities, electronic communication services and meeting rooms form a good environment for the new entrepreneur. The contact and mutual exchange of experience with other start ups add to the advantages of such centres. In many cases, managerial advice especially on the economic and marketing aspects of the start up are essential assets of the support offered by or via the centre management. There is no doubt, that these centres contribute to the succeful creation of new jobs and to the creation of a general innvative climate.

Of course, there are many start ups that will not use the facilities and services of centres. In addition, as has been mentioned before, the individual characteristic of every new technology calls for more diversified and flexible approaches. As a consequence, it should be considered to establish “virtual”, decentralized technology parks as network organizations connecting different entreprises with the research and consultancy support of a specialized department or a full university. On the basis of contractual arrangements long term but at the same time flexible cooperation should be possible. Making optimal use of the newly developing information and communication infrastructure (information super highways) such virtual technology parks will not be restricted to one location or region but can be organized as a network even at a global scale. The potential of interactive multimedia systems and computer supported collaborative work (CSCW) form a background on the basis of which new organizational concepts can evolve.

Finally, industrial boards as advisory bodies, alumni associations as sounding organisations can be mentioned as different forms of establishing continuous organisational links and feed back mechanism betwenn the university and “the real world”. The same is true for industrial members of curriculum development and examination committees.

The large number of different approaches, very often developed without plan on the initiative of a active individuum, shows that there are many options to support and enhance university-industry collaboration. Clear strategies, plans and decisions based on an integrated concept combining different approaches following the comparable strengths of an institution and taking into account its specific economic and social environment are surely more promisiong than leaving everything just to evolution and chance.

2.2 University-industry collaboration - a problematic relationship?

University and business are two different systems following different objectives and rationalities. The aim of enhancing university-industry collaboration must not mean to distort university to become industry or vice versa. It has to be accepted that the two partners in such a collaboration have different motives and objetives. The different characteristics of the two systems have to be managed, orchestrated or moderated in such a way that added value is created and innovative processes are enhanced.

Staudt proposed three conditions for success in thecnology transfer / X /,

- differentials between the partners, differences in know how, hardware, software and qualified personell,
- compatibility between “transfer object” and the receiving system,
- benefits for all partners involved.

The following table shows some differences between university and business,

Objectives and Priorities	
University	Industry
* academic freedom * immediate publication * collaboration * longterm basic research and creation of new knowledge * subject based research	* profit and commercial viability - time and money * secrecy * competition (“kill your competitor”) * shortterm commercial exploitation of new knowledge * mission oriented problem solving R&D
Legal status and management style	
University	Industry
* democratic decision pyramid * loosely coupled, decentralized management system * slow decision taking processes * vague mission (if at all)	* limited company with executive actors * centralized hierarchical management * fast and clear decisions * clear mission

But there are other additional problems, especially connected with university-SME collaboration. On the one side, one has to mention the limited "receptivity", the limited absorption/adoption capacity of new technologies of SMEs. On the other side, the universities show a limited "accessibility", they are complex organisations with sometimes more than hundred institutes, with divisions, departments and schools Thus, especially for persons without academic background it is difficult to find a specific expert for a collaborative venture. In addition, one has to take into account the fact that innovation in an entreprise cannot be started just by information on new technologies. Careful identification of needs is necessary. Very often, the organisatinal and management structure of an enterprise has to be changed to prepare it for the adoption and implemetation of a new technology. And, finally, the personnel should participate in the changing process and has to be prepared by appropriate training measures. Studies show that 50% of the success of implementing new technologies depend on the acceptance by and the qualification of the personnel.

Therefore, technology transfer has to be interpreted as a complex communication process between two different worlds, with different systems of codified objectives, rationalities, tacit knowledge and different management approaches, values and interests.

2.3 Some intermediate reflecations

A new interactive model has to be found on a higher level than either "technology push" or "market pull" to arrive at an integrated process oriented approach involving the main actor groups of the innovation system - especially researchers, developers, suppliers, technology users - in new forms of collaborative research and development. Further research is necessary on the nature of this "Second generation interaction" to prepare the ground for appropriate measures to support such processes.

Today, with respect to technology transfer the universities still can be compared to "super markets" offering research results "from the shelf" to the curious customer who is looking for something useful that might be developed into a profitable product or an efficient process in a further stage. The "scientific community" lives its self-contained life, characterized and controlled by publications in reviewed learned journals and presentations at expert conferences. There is no doubt, that this both sophisticated and well established evolutionary mechanism stimulating the aspiration to excellence is crucial for the production of new knowledge in general terms of intellectual and cultural advancement and for the innovation system in particular. The traditional proyect oriented peer review system, that is closely connected to this system, has its unquestionable merits, but at the same time it causes problems not only for newly evolving ideas beyond the boundaries of existing well defined subject areas but also for extremely innovative areas such as engineering sciences, because it is in most cases based on a traditional paradigm of science.

It might be an interesting topic to investigate in depths the philosophical and social roots of these problems. It seems, that, up till now, the shift towards a knowledge or really science and research based society has not been achieved at all levels of the system and in all its consequences. So, the knowledge creating and producing system - such as the universities - is still behaving/working following the rules of the pre-scientific society. Until recently, even industrial research followed the guidelines of academic research and is only since a very short while working aut its own characteristics, rationalities and procedures.

However, there is a new dimension to be developed. The existing system has to be complemented by well organized interaction processes with real life, with different parts of society, with the worlds of application.

User involvement and needs orientation is stressed in national and international policies, strategies and programmes. The European Union's 4th RTD Framework Programme emphazises the importance of user orientation more than any former programme. But there are many difficulties, barriers and uncertainties to overcome. In particular, there are the general problems of needs identification and analysis. In most cases, being asked, neither industry nor small and medium sized enterprises can clearly define their needs spontaneousely.

This is very much a communication problem and a specific task for the desing of appropriate social processes across the boarder lines of different social sub-systems. There, the universities could play an important role if they can elaborate and offer new appropriate management concepts, expertise and skills, This has especially to comprise the management of internal and external organisational networks.

3. Technology transfer and technology diffusion: A management challenge for the university

3.1 The importance of instititional strategies

Looking for conditions that constitute a supportive environment for university-industry collaboration and technology diffusion it is clearly seen that there is a new role for university management. It is interesting to note that since about 15 years there is a growing awareness that provisions at an institutional level are necessary to reduce the complexity at the interface between the university and "the real world".

Staudt proposed three conditions for success in technology transfer / X /:

- differentials between the partners, differences in know how, hardware, software and qualified personell;
- compatibility between "transfer object" and the receiving system; this means on the one hand a certain degree of marurity of the technology to be transferred and on the other hand appropriate potentials regarding technology, personnel and qualification as well as infrastructure on the side of the receiver;
- Prospective benefits for all partners involved.

There are several crucial aspects to be considered in systematically supporting university-industry collaboration:

- university-industry collaboration (UIC) has to be become a well defined part of the institutional mission and the organisational development plan of the university,
- UIC has to be considered positively in staff appraisal and must not be obstructive to academic career paths,

a well designed organisational support infrastructure with specifically trained personnel is essential.

A detailed checklist based on work undertaken in the UK by the Council for Industry and Higher Education and the Department of Trade and Industry (see Annex) gives excellent guidelines and a signpost for development of policies and strategies for collaboration with industry of higher education institutions. Main elements of this checklinst are

- mission, aims and objectives,
- auditing policy and performance,

assessment and evaluation,

- policy on costing and pricing,
- policy on intellectual property,
- policies for enterprise,
- strategy and structure,

strategies for quality.

In addition, some selected measures are of specific importance:

- create organisational structures, that present a clearly defined interface and access point for the outside world,
- a university management information system - especially a well structured information system on research potential of the university departments and their concrete research projects as a basis to identify strengths (and weaknesses),
- a coordinated set of interactive approaches to decision support, technology transfer and generation of collaborative projects,
- marketing services for selected research results,
- develop the continuing education activities as an important route for the dissemination of research results,

specific professional services for contractual arrangements and intellectual property rights (IPR),

- an integrated programme to support the start up of spin off companies,
- a well designed alumni programme to assure long term feedback links,
- developing specific strategies for the university's role and function in regional development and international collaborative programmes
- public awareness programmes for RTD.

In a way, the present problem area is one aspect of a general development in the course of which the university as an institution in itself - not just as the sum of its pepartments - that is managed, steered and controlled is just materializing. In Europe this is a rather recent development. There is a growing awareness that a professionalisation of institutional management of universities is necessary. An many cases, that has lead to the appointment of professional full time university management already.

3.2 The role of interfacial organisations

In many cases, in addiotion to the traditional individual links interfacial organisations - such as university extension centres, industrial liaison offices, technology transfer centres, patent and licensing offices etc - have played a decisive role to enhance the collaboration between university and industry, especially regarding small and medium sized enterprises. Such an organisation

- helps to facilitate acces from the market to the university and vice versa,
- reduces the complexity of the university and thus university-industry relations.

- is in a position to develop and execute programmes for selected target groups - such as SMEs - based on the identified strengths of the university,
- s able to create synergies between education (in particular continuing education) and research.

It is interesting to note that in continental Europe such institutions started to develop at the end of the 1970ies when it became gradually clear that science and research, knowledge are of highest importance for societal wellfare in general and economic success and competitiveness in particular. The universities strated to develop new profiles and new activities. They reflected more consciously on their role in society and started to organize their realtions especially to the world of business more systematically.

However, it must be taken into account that such central units need professional staff. There are some basic requirements that have to be fulfilled, to name just a few

- management knowledge, capabilities and skills,
- communication skills,
- knowledge and understanding of innovation process,

practical experience in research and development,

- general business and market insight,
- proyect management and marketing skills,
- ability to organize and facilitate (moderate) social processes

In a complex environment at the boarderline between two different systems, which are themself not homogeneous but highly differentiated, interfacial management has to organize target oriented interactive processes that are suited to strengthen the collaborative links between university and industry and create optimal mutual benefit and synergies on the basis of the differences of the partners.

3.3 A Practical Example: The University Extension Centre, Vienna University of Technology

3.3.1 Introduction

In 1980, a University Extension Centre has been established at Vienna University of Technology to form a central institutional basis for the enhanced development of science transfer and continuing education. Since 1989, the Centre is also responsible for stimulating the internationalisation process of the university in the framework of EC Programmes. Therefore, the main areas of activities are the following:

- research information and documentation,
- technology transfer,
- continuing education, and

international programmes and projects.

However, an integrated concept was applied at the University Extension Centre for all these areas on the basis of the above mentioned system-oriented approach.

3.3.2 FoDok Austria: A Research Information and Documentation System

A key factor for an interfacial unit is detailed information on the potential of the own institution. Knowledge on the potential and the concrete projects of the different departments as well as scientists of the university provides the basis for taking care of a continuous communication process between the university and its environment. Therefore, the Univesity Extension Centre established the research information and documentation system FoDock Austria which started its operation in 1985.

This research information and documentation system includes data from all Austrian universities and it basically consists of a database with detailed information on

- the different departments of the Austrian universities,
- its sub-units, as well as
its different research projects.

The data of every university are updated regularly every two or three years. Thus, FoDok Austria allows to access in a most precise way the research potential of all Austrian universities.

The basic data of the database are published as a handbook. More specific reports and investigations can be ordered at the University Extension Centre. Thus, the University Extension Centre acts as clearing house for the research potential of all Austrian universities

At the moment, a new project concerning the research information and documentation system FoDok Austria is designed. This project aims at preparing an appropriate infrastructure and network of partners for

- developing a partially decentralised model of retrieval,
updating the data on shorter intervals,
- establishing new distribution channels, and
- connecting FoDok Austria with other international initiatives and databases, e.g. in the framework or the European Working Party for Research Project Data Bases.

3.3.3 Technology Transfer

3.3.3.1 Cooperation with the Viennese Economic Chamber

In addition to the institutional basis provided by the existence of the University Extension Centre itself, a specific framework for the activities in the field of technology transfer has to be mentioned. In the year 1987, a long-term cooperation agreement between the University Extension Centre and the Viennese Economic Chamber was signed. General goals of this contract are:

- to identify promising technological areas for further development, and
to generate and organise cooperative actions

considering

- the international state of the art and new trends in technological development,
- the specific strengths of Viennese enterprises, and
- the potential with respect to academic staff and infrastructure of the Vienna University of Technology.

In more details, the Viennese Economic Chamber expects to strengthen the innovative capacities of the Viennese enterprises through better access to the R&D potential of Vienna University of Technology and to contribute to the improvement of qualification of the staff of these enterprises by coordinated development of and unproblamatic access to continuing education offers of Vienna University of Technology.

The Vienna University of Technology expercts from this cooperation further suggestions for practice-oriented R&D projects by better information on the needs of Viennese enterprises, possibilities for attracting external funds from Viennese enterprises by R&D cooperation, and a braoder information on the qualification needs of Viennese enterprises.

In order to reach the mentioned goals, one academic staff member at the University Extension Centre is financed by the Viennese Economic Chamber. The range of activities applied is the following:

- telephone advise on expertise and scientists at the Vienna University of Technology,
- presentation of the cooperative potential of university departments,
- information events “research for industry” on various scientific topics, and
- technology transfer conferences for presenting the cooperation potential of faculties of Vienna University of Technology,

After two years, this cooperation was reviewed and evaluated by external consultants. The results of this evaluation were rather positive except that basically only industry took advantage from the offered technology transfer activites. Therefore, the University Extension Centre in cooperation with the Viennese Economic Chamber generated a project focussing especially on SMEs.

This project aimed at

- identifying different factors which facilitate or impede a cooperation between SMEs and the university,
- identifying possibilities for innovation and technological problem areas in the SMEs,
- developing appropriate measures for stimulating the cooperation between the university and SMEs, and
- strengthening the innovation potential of the SMEs through more intensive cooperation with the university.

At the beginning of the project, the target group for the activities was defined. First, a specific brunch of SMEs, namely the metal processing brunch, and a limited number of enterprises were selected in cooperation with the Viennese Economic Chamber.

Next, more than 70 companies were visited and representatives of these companies were interviewed in order to

- identify factors, which facilitate or impede cooperation between SMEs and the university,
- identify structure of cooperation which are most appropriate to stimulate the cooperation,
- make the project known in the respective business sector, by addressing multipliers within the brunch, and
- initiate specific cooperative activiies between the respective business branch and the university.

The most important barriers for coperation which were mentioned during the company visits were the following:

- "I don't have time for cooperation",
"Vienna University of Technology is not a competent partner for my problem",
- "Cooperation with the university is risky",
- "Scientists don't know practice",
- "The university works too slowly",
- "Supported cooperation is too bureaucratic",
- "Confidentiality is not guranteed",
- "I don't have any idea what the university could offer", and
"My problem is too small".

As a result of this exercise, about 20 concrete cooperative projects between SMEs and the university were generated.

In addition, some of the measures of the University Extension Centre in the field of technology transfer were adapted and new ones were developed. Finally, it should be mentioned that about 1.000 persons participated in the various technology transfer activities during the last academic year. About 40% of them came from SMEs.

3.3.3.2 Stimulating internal awareness

In addition to concrete measures in science transfer, it is also necessary to continuously reflect the framework conditions, possibilities for further activities as well as problem areas. Therefore, the University Extension Centre is organising seminars and other events focussing on specific aspects of technology transfer and technology policy relevant for the cooperation with industry.

Seminars on "Setting up a new enterprise" or information meetings on "Legal aspects of contracting", etc. are examples from the last years. The target group for these events is basically the academic staff of Vienna University of Technology.

This internal awareness programme is aimed at supplementing the other activities of the University Extension Centre to stimulate a more intensive cooperation between the Vienna University of Technology and industry.

3.3.3.3 Moderated Strategic Technology Assessment

The area of science transfer is not only seen in a short-term perspective focussing on transmitting knowledge existing at the university which might be reduced to a specific application, identified, transferred and used. In a long-term perspective, the design and moderation of appropriate communication processes are of central importance. Complex communication processes have to be generated between the sub-systems involved in technological development, i.e., science, economy, administration, funding institutions and the social partners, in order to support decision making processes, to stimulate tuning processes, to identify priorities, to generate cooperative activities and to identify qualification needs.

Based on this background, a specific approach for moderated strategic technology assessment has been developed at the University Extension Centre. This approach aims at identifying for a specific technological area the following aspects concerning:

- to gather information on the international state of the art and the Austrian situation in the respective technological area,
- to identify strengths of Austrian science, engineering and industry,

to assess possible priority areas for the further development in Austria, and

- to identify necessary additional measures such as appropriate forms of cooperation between science and industry, dissemination of information and continuing education courses.

This approach provides a methodology for an interactive method of technology assessment and decision support and in addition it stimulates concrete cooperative actions.

The different elements of the procedure can be presented in the following seven step procedure (Horvat and Wimmer 1988, p44 ff.).

1. identification of a key technology area
2. a preliminary description of the state of the art in the area
3. formation of a small academic core group

3.1. defining problems and goals

3.2. developing alternative solution strategies

3.3. preparing a concept for the moderated, interactive process

4. moderated, interactive assessment in an expert group answering the four questions on:
   international state of the art and foresseable trends, Austrian strengths and weaknesses, recommendations on priority areas for future developments in Austria, necessary flanking measures
5. evaluation of the results of the moderated interactive discussion process in the seademic core group
6. public presentation and discussion of the results in a workshop with all main decision makers in the area in Austria
7. follow-up activities

Early warning and decision support systems become more and more important in technology policy in defining priority areas for future investment. The University Extension Centre

is convinced that the university has to play an important role in this context and is actively approaching this field.

3.3.4 Continuing Engineering Education

Continuing education was one of the priority areas of the University Extension Centre from the beginning of its existence. It is seen as an important measure of technology transfer by dissemination of expert knowledge and dissemination of new research results. More indirectly, it continuing education provides a forum were professional engineers meet teaching university researchers. There, people from the two different worlds get acquainted with each others, discsuss problems and possible collaborative ventures. Very often, from af irst contact in a continuing education cource consultancy and research contracts cam result.

The courses offered mainly should give the participants the possibility

- to update their knowledge or
- to provide access to the relevant new results in selected technology areas

The target group for the continuing education courses is basically graduates of the university and other employees who fulfil the conditions for participation because of the activities in their professional career.

The subject areas for continuing education offers are mainly identifiel on the basis of the following procedures:

- moderated strategic technology assessment activities,
- technology transfer activities,
- requested retrieval on university research,
- qualification needs analysis, and
- offers and consultations with the academic staff of Vienna University of Technology.

At the moment, the University Extension Centre offers about 50 short courses and about 20 continuing education programmes. The duration of the short courses varies from one day to one week. Many of the longer programmes last for several weeks up to two years.

For the longer programmes, especially for interdisciplinary programmes, it is most valuable to apply a cooperative procedure in planning and designing the programmes. This means that the programmes are not ready made products but that the academic staff as well as potential customers are actively involved in the preparatory phase. This procedure is important for offering needs oriented courses as well as for the marketing of the programmes.

Continuing education can act as sort of an “avant garde” for university teaching activities, as a test bed, and it in general it provides an important feedback plarform between the university and the world of business.

3.3.5 Internationalisation of continuing education and R&D

Since several years, the University Extension Centre is most active developing an international dimension in its continuing education activities and based on this experience also in the area of European research and technology development programmes,

In the framework of COMETT, two UETPs - University Enterprise Training Partnerships - were established. The UETP DANUBE is a regional UETP. It was established in 1990 and covers many diferent sectors and the regions of Vienna, Lower Austria and Burgenland. The UETP EuroLaser, a sectorial EUTP also started by the University Extension Centre, started its activities in the year 1992.

As a first result of this activity in COMETT, several courses involving international lecturers have been designed and offered in cooperation between the UETP DANUBE and the University Extension Centre, since 1992.

4. National and European policies and strategies

4.1 introduction

There is general agreement the science and technology play central roles in economic and social development. Thus, it is only natural that science and technology have become an important issue of government policies at the national level and of Community activities at the European level.

However, in the past very often policies concentrated mainly on the support of technology development. Technology transfer so far was in most cases interpreted as and - at best - confined to the dissemination of information regarding newly available technology.

Experience shows that successful innovations excel by taking into consideration technical, economic, management, social and human factors, the main barriers to adoption of new technologies being:

- lack of qualified personell (appropriately skilled technical and managerial, personnel),
- high real cost of capital,
- lack of technical standards,
- deficits in managing the full potential of the new technolocy,
- short-term business strategies,
- availability of new technologies,
- long depreciation periods for capital equipment,
- government regulations that promote the use of domestically produced technology (which might be inferior to that available on the international market).

Policies have to focus on overcoming multiple obstacles (OECD 1988, p76). A cluster of reinforcing policies, combining both micro- and macro-level components - conditions that promote competition and favour long-term capital investment are of particular importance. Asked for the one single most important factor, however, that surely is human capital.

As has been described, it is important to note that technology development and diffusion are highly interactive processes with many actors involved - government, universities and other research organisations, industry and small and medium companies (SMEs), funding organisations, the social partners, and - last but not least - public opinion

There is a noticeable shift in thinking regarding dynamics of technology development to a systems approach dealing with the interaction of interrelated processes, where, so far, technology development has been described as a supply driven sequence of separated elements comparable to a relay race - R&D, development, engineering, production, marketing etc.

Knowledge has to be seen as the fundamental resource. Thus, the generation of knowledge, and the facilitation and support of learning process are assential at all levels, including the systems level. But formally codified and un-codified knowledge have to be distinguished. How about the transfer of tacit knowledge, the information on contexts. Institutional and organisational aspects have to be taken into account. In addition, knowledge distribution and absorption capacities play a decisive role.

There is an enormous underusage of knowledge and at the same time a vast amount of duplication of knowledge generation (Ye-inventing the wheel").

So, dealing with technology transfer aspects of S&T policy, objectives have to be set to support the development of complex integrated process-oriented interdisciplinary approaches rather than simplistic technology information and marketing campaigns that - in the long run - create only frustration and scepticism against new technologies.

In the present context, not all aspects of technology policy are dealt with, but only some key aspects relavant for the technology transfer problem area.

4.2 Regional and national policies, strategies and programmes

In connection with research and technological development, in Jacques Delor's White Paper on "Growth, Competitiveness, Employment" there is a clear distinction between necessary measures on the member states'level, Community measures and concerted or coordinating actions.

An interesting process can be witnessed: on the one hand one can observe a growing internationalisation, or even globalisation of economic and technological development. In that connection, there is a need for a certain amount of harmonisation at the systems level to pave the ground for transnational collaboration, partnerships and strategic alliances. National policies become important because e.g. guidelines and signposts are necessary to define a state's specific position in international collaborative programmes and initiatives. This leads to a certain extent to the identification of specific strengths of a region or a state, that means to a clearer profile or - in international comparison - to a diversification.

There is no doubt, that in regional and national affairs technology has become an important aspect for assuring welfare, competitiveness and employment, too.

For national initiatives The White Paper mentions indirect regulatory instruments, such as tax credit schemes, to incourage enterprises to invest more in science and research. “The Member States could also study and introduce schemes to lighten the social security contribution burden on firms and research bodies creating new jobs for researchers and engineers together with financial and career incentives for further on-the-job training for the scientific and technical staff in service.”

Such actions could also promote the dissemination of knowledge and of new technologies There are existing highly successful programmes like the UK Teaching Company Scheme and similar approaches, that have already been mentioned before. Also schemes for helping researchers to start up businesses are recommended. Risk capital is seen as an important instrument to set SMEs in the position to adopt and develop technologies into successful innovations.

A well designed set of operational mechanisms is necessary to enhance the collaboration between university laboratories and companies. There are some key policy aspects forming a supportive framework for technological innovation:

- improving the access to national and international scientific and technical information.
- financial services,
- aid to protect innovation,

training in strategic technology management and in the management of innovation,

consultancy support for the introduction of new technologies (needs analysis, technology search and assessment, management and organisation, human resource development).

Technology priority programmes play a role, but there are many considerations how to develop new procedures to improve design processes and coordination of national research and technology policies involving the main actors. In connection with that, the representation of the small and medium sized enterprise sector is a special problem.

There is a cautious shift in governmental university policies orienting research and higher education towards considering industrial needs. There are numerous different programmes and initiatives in different countries to foster university-industry collaboration and technology transfer. There is, however, considerable concern as to how far universities should go in their orientation towards business needs. There is the danger that curiosity driven basic research is dried up and thus the “fertile soil” on which invention and subsequently innovation grow is destroyed.

Although there are many differences between European countries, it can be said in general that this development is gradually leading to higher education and research systems that are more oriented towards practical application, short-term and commercial benefit than in the past. To a certain extent, this means a fundamental change of academic culture and in the relations between university and society. Finally, the industrial orientation could influence the common publication procedures characteristic for academic institutions. If the publication of research results depends on agreements from industrial sponsors because of proprietary considerations scientific knowledge is never more a “public good” as has been a fundamental notion, so far.

One of the basic notions of academic life has been the notion of the combination of research and education. However, very often, research had a priority status. There is a growing awareness that better synergies are nesessary between research and education, This materializes in new policy lines in government and European programmes, but strong efforts are necessary to fill these objectives with the life of appropriate strategies and actions.

Increasingly, national policies take account of the needs of international technology transfer that is closely connected to the European Union's framework programmes. The EU specific programmes contribute to the creation of interorganisational networks and strategic alliances between enterprises and between enterprises and universities. There are national policies and initiatives to enhance the participation of companies and research department in these programmes, supporting the integration of researchers in international know how consortia. The most important tasks in this respect are

- coordination of national and European policies and programmes,
- identifying the strengths of the netional research and technology system and the opportunities to collaborate on an international scale,

strategic early warning on forthcoming programmes,
- consultancy and advise in connection with the preparation of proposals,
- partner search,
- management advise,
- support in dissemination and exploitation of research results.

In Austria, like e.g. in the Netherlands, a central organisation, the Austrian Bureau for International Research and technology Cooperation (BIT), has been established in a coordinated action by the technology relevant ministries and the Austrian Economic Chamber, as a national operational agency to support the integration and participation of Austrian companies, university departments and research estabishments in European and international research and technology programmes and initiatives. The BIT follows a strategic approach networking with the Commission, other service organisations in all countries in Europe, different institutional and sectorial networks and all kinds of interfacial organisations in Austria and abroad.

4.3 European policies and strategies

European actions in research and technological development are focused under the umbrella of the Framework Programme. At present the 4th Framework Programmes is in its starting phase. There will 20 specific programmes under four lines of activities:

First Activity:
Research, Technological Development and Demonstration Programmes
Second Activity:
Cooperation with Third Countries and International Organisations
Third Activity:
Dissemination and Application of Results
Fourth Activity:
Stimulation of the Training and Mobility of Researchers

The objectives of the Framework Programme are to improve the competitiveness of European industry and the quality of life in Europe, and to support other Community policies. The programme concentrates on generic technologies that contribute to the development of many industries in a crossectional way. The selected technology areas are

A. Information and Communication Technologies
   1. Information Technologies,
   2. Telematics,
   3. Advanced Communication Technologies and Services;

B. Industrial Technologies
   4. Industrial and materials technologies
   5. Measurement and testing

C. Environment
   6. Environment and climate
   7. Marine sciences and technologies

D. Life Sciences and Technologies
   8. Biotechnology
   9. Biomedicine and Health
   10. Agriculture and Fisheries

E. Energy
   11. Clean and efficient energiy technologies
   12. Nuclear fission safety
   13. Controled thermonuclear fusion

F. Transport

G. Targeted Socio-economic Research

In budgetary terms the European RTD Programmes present only 4% of the EU budget and also 4% of the total public spending on RTD in the Membe States. However, they are of strategic importance because they reduce some of the characteristic deficits of the European innovation system. They contribute

to the coordination of national and EU policies,
to the creation of transnational collaborative networks,
to the international technology transfer,
to human resource development through the training ad mobility of researchers,
- to the dissemination and exploitation of research results.

Focusing on the last point, there are three important actions in the 4th Framework Programme:
- 1% of the overall budget is devoted to fund dissemination and exploitation of research results as an integrated part of the specific programmes;
- education and training will play an important role as flanking measures for the specific programmes
- a special action (Third Activity) for the dissemination and exploitation of research results from the specific programmes.

In the Third Activity both practical measures to organize and support the dissemination and exploitation of results are taken and - at the same time - appropriate instruments, tools and procedures are developed. The Activity comprises measures such as

- specialized organisational infrastructures (the network of VALUE Relay Centres, the SPRINT Networks),
- technical infrastructure and services (Community R&D Information Service - CORDIS),
- services to support the protection of know how (IPR).

At the moment, the coordination between the dissemination and exploitation activities under the Third Activity and under the First Activity is discussed. Recently, the establishment of a cross-programme Task Force has been proposed to work in this direction.

In addition to the aspects described so far, in the specific programmes under flanking measures there is a growing importance devoted to the training aspects as a means for the dissemination of research results, that means technology transfer. There are many important links between education and research. With this new focus the important synergies between research and training are emphasized.

In the discussion on long-term industrial competitiveness in Europe the dissemination and exploitation of research results is an important problem area. There is growing concern that the traditional channels of dissemination - presentation at specialists conferences and publication in learned journals - are not sufficient to integrate research findings into the innovation cycle, since by publication in expert journals and presentation at specialised conferences the boarder line between the scientific community and the worlds of application are not crossed. There is a need to explore and develop other communication channels such as continuing education and training. The activities foreseen in the Fourth Framework Programme seem to be steps in that direction. There are several barriers to be overcome when exploiting R&D results and implementing new technologies. This is taking into account of the fact that human barriers such as the acceptance of new technologies and the missing competencies to adopt, adapt and develop R&D results and implement new technologies are the most important barriers in the innovation process. In a way, continuing education and training could be the missing link between R&D and innovation, where, at the same time, continuing education counld form a communication channel between researchers and the market of growing importance.

5. Conclusions

University-industry collaboration and technology diffusion are complex social communication processes across the boundaries of different systems with different objectives and rationalities. Simplifying interpretations, concepts and approaches will not lead to success in terms of industrial innovation and competitivity but will lead to failure and thus widen the gap between the industrial and the academic world.

In the present paper, technology transfer is interpreted as the complete process of innovation and technology diffusion, where technology development comprises the invention (ideas for new technology, research being one of the main sources) and innovation (inventions transformed into commercial applications) with the supply of new technologies as a prime

focus. Technology diffusion means the spread and adoption of new technologies and their application.

University-industry collaboration is a challenge to the organisational development of the universities that have to define the rules and to develop appropriate instruments for collaboration

Interfacial management at many different levels has to be system oriented, non-hierarchial, facilitating - and continuously learning.

Technology policy has to take account of technology transfer and support the development of integrated approaches that are appropriate to the complexity of the problem.

Several other aspects have to be added in further elaboration of the analysis of the technology transfer process. There are just two aspects to be mentioned

technology transfer always is selective; that means that forecasting and assement of technologies has an important role to play to support decisions;
- the role of tuiding principles, criteria and values - such as sustainable development, environmental and social quality, new concepts of efficiency and effectiveness - has to be explored.

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ANNEX

POLICY AND STRATEGY FOR COLLABORATION
A SELECTIVE CHECKLIST FOR HIGHER EDUCATION INSTITUTIONS[1]

1 MISSION, AIMS AND OBJECTIVES

What parts of our mission have been defined for us by external bodies?

What parts of our mission have been defined by ourselves?

What are our principal objectives for the next planning period in terms of teaching, research and service?

To what extent are relationships with business likely to contribute towards achievement of these aims and objectives?

2 AUDITING POLOCY AND PERFORMANCE

In what areas have we either under-performed or exceeded our planning targets during the current or recent planning period? To what extent, if any, have relations with the relevant section of business been contributory to this outturn?

What changes in the external environment (e.g. social, demographic, technological, political, fiscal), likely to affect our work in the next planning period, are relevant to our relations with business?

What is (a) our policy and (b) the current position with regard to the following:

- business contributions to the planning of courses, to teaching, supervising and to assessing student performance

1. These checklists are based on work undertaken in the United Kingdom by the Council for Industry and Higher Education and the Department of Trade and Industry

Commission of the European Communities: European Higher Education-industry Cooperation: Advanced Training for Competitive Advantage. Task Force Human Resources, Education, Training and Youth Brussels, 1992

- business support and sponsorship for students (including both national schemes and local arrangements)
- staff secondments to and from business
- academic and research posts endowed or supported by business, and the contracts on which such appointments are held
- research, development and contract consultancy work undertaken for industry and the public sector
- donations of equipment and services from industry or business
- the terms on which academic units and individual staff members undertake consultancy and contract work for third parties, especially costing and pricing policy and practice
- the ownership of intellectual property
- access by industrial and other bodies to institutional facilities eg the library and online databases; the evaluation of computer hardware and software; specialised research equipment; language teaching centre
- the letting status and level of interactive activity with any science park or high technology development with which we are associated
- the financial and trading status of companies set up with our support or in the work of which groups of staff are actively engaged
- consultancy assignments undertaken?

3 ASSESSMENT AND EVALUATION

Is the overall pattern of existing collaboration consistent with our missions, aims and objectives?

Do existing forms of collaboration reflect our strengths or compound our weaknesses?

Do the forms of collaboration presently in place contribute to our financial viability, responsive capacity and academic reputation?

Are there some subjects and professional groups currently not in dialogue with business and without collaborative arrangements in teaching and research, but which have potential for fruitful forms of association? What needs to be done to release this potential?

Are there gaps and deficiencies in administrative arrangements and in incentive and reward structures that currently inhibit effective working together?

Do our student admission policies give due weight to business experience and to non-standard qualifications?

What action is needed, and by whom, to ensure that we are not missing out on opportunities for working with business that will strengthen our academic and financial position and enhance our reputation?

4 POLICY ON COSTING AND PRICING

Is there an agreed policy on costing and pricing contract work, known to and understood by all staff, which takes account of its contribution to knowledge and long-run potential for royalty and other payments?

Are there suitable arrangements for giving advice to staff involved in negotiating projects?

Do appropriate formulae exist for the calculation of indirect attributable costs, and for the distribution of income between the individual, his or her department or other academic unit and central funds?

Have we available appropriate sources of legal advice on any risks and liabilities that contract work may entail?

Do we have in place quick-acting and detailed budgetary control systems, which require monthly departmental returns on achievement vs. budget under main cost headings; rigorous credit control; effective bad debt recovery; prompt and efficient methods for preparation of quotations and strong central control of planned surpluses on contracts?

5 POLICY ON INTELLECTUAL PROPERTY

Do we have a policy on intellectual property that is known to and understood by all staff, and which takes account of comparable policy and practice elsewhere?

Is this policy incorporated into staff contracts and conditions of service?

Is it undersstood that students involved in the development and exploitation of intellectual property are to be treated on the same basis as members of staff?

Is authoritative advice available to members of staff at each stage in the process of identifying, developing and exploiting intellectual property?

Are there means for resolving any disputes that may arise between individuals and with the institution concerning the ownership of and distribution of income from intellectual property?

6 POLICIES FOR ENTERPRISE

In what ways do our senior members seek to encourage closer and more effective relations with business?

Are academic units expected to report upon current activity and make known their plans for working together with business?

Are our practices in respect of academic advancement and recognition consistent with our policies on industrial collaboration?

Are individuals and academic groups rewarded for success in working with business through internal resource distribution or other means, in ways that motivate them to further successful effort?

Do our policies in this field take account of the experience of and attitudes to business that students bring with them from school, college or employment, and how these affect their expectations of higher education and of employment?

Are our students brought into contact with facilities for vocational guidance at a sufficiently early stage? Do such services assist students to formulate career intentions that are realistic in terms of personal capacity and external opportunity?

Do we have in place staff development programmes that encourage teaching and supervisory practices consistent with the development of transferable skills, self directed learning, clear perceptions of individual strengths and weaknesses, and the ability to make decisions and accept personal responsability?

Do students have opportunities for extra-curricular activities that enhance their employability and subsequent work satisfaction?

Are men and women working in business actively involved in the governance, teaching, research and service activities or our institution?

7 STRATEGY AND STRUCTURE

Are effective arrangements in place for industrial liaison and the stimulation of business contacts?

Are we effective in marketing our strengths and making known to potential collaborators ways in which we can help their businesses?

Have the costs and benefits of maintaining and establishing wholly owned or partnership companies to undertake particular activities been fully calculated and the results of these calculations acted upon?

Is our current and planned involvement in any property-based development of such nature as to encourage interactions that have positive academic and financial benefits?

8 STRATEGIES FOR QUALITY

Do we have a quality policy that embraces all aspects of our work and which encourages individuals to take direct responsibility for the quality of their own performance?

Are our procedures for the recruitment, motivation, assessment and development of staff consistent with our quality commitments?

Do we call upon men and women from business to help us in the assessment of our performance and in maintaining standards appropriate to our objectives?

Have we considered what relevance the concept of 'zero-defect' might have for our work, especially in our relations with business?

Can we offer quality in project management of a kind that carries conviction with our business partners and collaborators?