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Academia-Business Links in UK and Germany: Policy Outcomes and Lessons Learnt

Conference Report

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Compiled by Rüdiger Wink

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Background

The academic world is undergoing rapid change – scientists and students are identifying new opportunities as entrepreneurs, multinational companies are basing their investment decisions on proximity to leading research centres, and policymakers throughout Europe are looking for new incentive schemes to maximize the economic and social output from academia, to prevent brain drain to the US, in particular, and to support the emergence of regional innovation systems around universities and public research organisations. Two key and oft-cited trends have prompted this unprecedented interest in the world of business:

(1) the emergence of 'knowledge economies' in which science-driven technologies are developed in an absence of clear boundaries between basic and applied research, and in which a high level of (academic) qualification is becoming a prerequisite for employment in the industrial and service sectors, and
(2) the internationalisation of markets, leading to ever-increasing mobility of financial and human (scientific) capital, and influencing the geographical patterns of academic excellence.

Even after the bursting of the 'Internet bubble' on capital markets, putting an end to any illusions of never-ending growth on the part of information and communication technologies, and casting doubt on the sustainability of many biotechnology business models, there is still a 'new economy' for academia-business linkages. This is because firms in the science-driven sectors can only be expected to survive if excellent science is translated into convincing new products and services.

For a long time, debates on the economic impacts of universities and public research organisations were confined to investigations of the impacts of demand on the part of academic staff and students. Nowadays, with knowledge as the key production factor affecting growth potential, the academic community is acquiring a new function within economic systems. New business options have been created for all academic activities – not just for research, but also for teaching and consulting. All components of the knowledge value chain – from generation and examination to exploitation and dissemination – are affected by universities and research organisations, leading to the expectation that academic institutions have a central role to play within innovation systems. However, there is still some confusion about how academia is to produce the impact expected of it. Is there a greater need for new linkages, or for more scientific excellence? Compared to their US counterparts and the success achieved by the latter over the past three decades, European academic institutions still seem to be less well prepared for these changes in the broader environment and the expectations levelled at them. In many European countries, researchers must choose between academia and business, since activity in one field will lead to rejection by the other. Particularly those researchers who are accustomed to lifelong employment by public authorities see only a limited attractiveness in producing knowledge for private markets, where the risks (but also the opportunities) are greater. Within the business community, lack of experience with scientists, scientific knowledge and its uncertainties has generated misunderstandings of the real potential of academia-business interactions. In many cases, the two sides (academia and business) seem to use different language codes and are permanently suspicious of being exploited by the respective other. Achieving the EU's Lisbon objective of becoming the world's leading market by 2010 will critically depend on these barriers being overcome.

Most European governments have therefore been trying to change the prevailing incentive schemes within academia and business in order to foster the emergence of new markets and cooperation. Many policy fields are affected by these changes. Examples include:

- *science and technology policies:* seeking new evaluation criteria, new funding schemes (including competitive structures), and new strategies (including the emergence of systemic and evolutionary approaches),
- *policies regarding intellectual property rights:* developing greater incentives for using patents as strategic assets in international trade, by extending the range of patents and by fostering their exploitation through technology transfer offices,
- *financial markets policies:* seeking support for academia-business links from venture capital markets and mezzanine instruments,
- *regional policies:* strengthening the decentralisation of political competencies and supporting the emergence of new public and private organisations to be integrated into regional networks as incubators for academia-business linkages,
- *education policies:* stressing the internationalisation of higher-education degrees, the importance of entrepreneurial skills and enhancing conditions for the supply of further education, and
- *industrial policies:* reducing entry barriers to new markets and improving access to a scientific knowledge base.

The papers presented at this conference by leading scientists from Europe, USA and Israel provide an overview of experience gained with policy changes in the field of academia-business interactions from a theoretical and empirical perspective. Given that these policy changes affect many diverse objectives and activities, a restriction to selected issues at the heart of policy debates was necessary. The main issues addressed by the conference were:

- Which changes in academia-business linkages can already be observed at university, industry or regional level?
- What can theoretical analysis tell us about the effectiveness and efficiency of current policy approaches to the fostering of academia-business interactions?
- Which recommendations can be given for further theoretical improvements and new policy initiatives?

This Final Report presents a collection of ideas advanced by the contributors with regard to four main topics:

- general challenges for academia-business linkage policies in the UK and Germany,
- academic entrepreneurship and policies to support the emergence of these options,
- the regional dimension of academia-business linkages, and
- the sectoral and technological dimension of academia-business linkages.

Several papers have been compiled in: *Rüdiger Wink (ed.), Academia-Business Links. European Policy Strategies and Lessons Learnt, Palgrave, Houndmills, 2004*.

1 General challenges for academia-business links policies in UK and Germany

Introduction

The conference started with an introductory statement by *Charlie Jeffery*, Deputy Director of the host Institute for German Studies at the University of Birmingham. He referred to the general background of UK regional policies. The English Regions White Paper, published in May 2002, proposes a framework for strengthening regional governance arrangements. On the way to establishing elected regional assemblies, higher education institutions have a role to play as stakeholders, particularly in the fields of economic development and skills. In February 2003, the Higher Education White Paper stressed the role of higher education institutions (HEIs) in the regional economy. HEIs also contribute towards social inclusion, which has an important regional dimension in practice. In order to fulfil these roles, higher education institutions must define their mission, identify suitable policy instruments and relevant actors for cooperation. Most importantly, new forms of assessment must be developed in order to gain a clear picture of the inputs that higher education institutions make to regional development and social inclusion.

Measuring and funding the 'Third Mission': the UK debate

Jordi Molas Gallart from the Science and Technology Policy Research Unit at the University of Sussex gave an overview of the challenges and prerequisites involved in assessing activities receiving Third Stream funding, which supplements the other two funding streams to support teaching and research.

In general, funding for UK higher education institutions (HEI) is channelled through the Higher Education Funding Councils in the various regions – the Higher Education Funding Council for England (HEFCE), the Higher Education Funding Council for Wales (HEFCW), and the Scottish Higher Education Funding Council (SHFEC). Since 1999, these councils and the Department of Trade and Industry have allocated Third Stream funding through tendering-based programs that mainly support entrepreneurial activities. These initiatives include the Higher Education Innovation Fund (HEIF), the Higher Education Reach-out to Business and the Community (HEROBC) initiative, and the University Challenge and Science Enterprise Challenge schemes.

With Third Stream funding increasing in importance, there is a growing awareness that such project-based resource allocation would prevent universities from developing long-term Third Mission strategies. Third Stream funding is not only very small in relation to the other two streams, but is targeted to specific well-defined sets of projects and short-term strategies. Once a project has been completed, the recipient university must seek additional funding for other related activities from other support programmes.

To enable longer-term planning of Third Mission strategies, universities, government and other stakeholders are exploring the possibility of developing permanent Third Stream funding mechanisms. It is hoped that continuous funding streams will reduce the dependence on discrete project bids and the uncertainty associated with such procedures. The objective of permanent funding strategies would be to provide core funding to help HEIs develop organisational practices to promote the transfer of knowledge and skills, and to enhance their linkages to the business community and society at large. Permanent funding could also provide a further incentive for universities to take a more serious look at Third Stream activities. Yet the transition from a 'project and bidding' form of funding to the establishment of new forms of permanent support is not straightforward. New criteria for resource allocation must be developed, and this on a long-term basis. It is important that such criteria are based on evidence of the needs or performance of Third Mission activities, or both. Data is needed to support such evidence-based policy implementation.

The development and assessment of these data raises some fundamental issues: (1) the definition of the 'Third Mission' itself, given the controversies about the relevance of entrepreneurial activities, cooperation with business or so-called 'community streams' supporting local communities in solving social inclusion problems under the Third Mission; (2) the balance across missions, i.e. the relationship of the 'Third Mission' to the other functions of universities (teaching and research), in particular the commercialisation of education and its relationship to traditional values of 'liberal education'; (3) the need for new instruments and concepts for data collection; (4) the need for coordination between isolated data collection approaches by individual researchers, (5) giving consideration to differences between disciplines and universities following different objectives, working in different market environments and therefore exerting different degrees of influence on regional development and social inclusion; (6) the need for greater motivation to apply benchmarks and conduct measurements within the university system, despite existing burdens in this regard; (7) the need to consider the unintended effects of new metrics due to the creation of new incentives; and (8) the need to examine correlations between the different missions in order to prevent multiple measurement and funding. Within the next few years, we will probably see some new initiatives by HEFCE and university organisations (e.g. the Russell Group of Universities) to develop new data sets and funding allocation systems for this third stream.

German and British biotechnology policy compared

Biotechnology has become one of the major science-driven sectors characterised by close linkages between basic research and product development. The UK and Germany are the leading European countries in this sector, in terms of the number of purely biotechnological firms and total workforce size. *Rebecca Harding*, Senior Economist of the Work Foundation, one of the leading UK think tanks at the interface between economic research and business expertise, presented an overview of the differences in biotechnology policy concepts in the UK and Germany. Whereas the UK model has been characterised as a 'market facilitation approach' based on private initiatives and early emergence of clusters around Cambridge, Germany has implemented a 'market creation approach', but only at a relatively late stage in the mid-1990s. Due to the lack of private-sector funding, Germany has established a public-sector VC market and has supported network structures at the regional level. Although measurements of the effectiveness of these policies are still hard to find, important differences can be identified in attitudes towards academia-business links within these technology policy fields, and in the structure of regional clusters:

- Between 1998 and 2001, the number of firms dedicated purely to biotechnology increased dramatically in Germany. However, most of these firms are still concentrated in niches as technology providers, and the actual size of the firms is smaller than their UK and US counterparts.
- In the UK, the number of companies also increased until 2001. The firms are concentrated geographically in regional clusters such as Cambridge and Manchester. There are tensions between scientists and biotech managers which tend to block the rapid dissemination of new scientific results.

Future research on biotechnology business and policy should address the following issues:

- Firstly, policy has involved a 'leap of faith', and measuring its effectiveness has proved difficult. New measurements that incorporate the tacit knowledge transfer and network development intrinsic to biotechnology research are needed. In short, we need to be able to measure 'symbiotic tension' between science and business, and its effect on the growth of biotechnology.
- Secondly, Germany has a greater number of 'platform technologies' – i.e. equipment and supplies or drug delivery systems with clear commercial potential, as opposed to the UK, which is still more research-oriented. This may be due to differences in the applied research funding structure and in particular to the use of equity-based finance in the early stages of biotechnology start-ups. The financing of biotech firms warrants further investigation, since it may well be that the form this takes will fundamentally affect the trajectory along which biotechnology research develops.
- Finally, the management of small biotechnology firms is an interesting area for further comparative research. This has been conducted in some detail for Germany, but there is scope for expanding this to a much more extensive level in order to examine the impact of networks on the trajectories of biotechnological development.

The role of intellectual property rights regimes for R&D cooperation between industry and academia

Ulrich Blum and *Simone Müller* from Dresden University of Technology focused on the role that institutional incentives play in motivating university researchers to cooperate more with business. Intellectual property rights (IPRs) are essential instruments for protecting the private use of new knowledge, despite such knowledge having the character of public goods. Yet coordination between academia and business on the use of IPRs via licenses is restricted because of knowledge asymmetries between researchers (agents) and firms (principals), since researchers know more about the real potential of patented knowledge and can exploit this advantage opportunistically. Three constellations are possible:

- quality uncertainties, where behaviour before conclusion of contract is determinable, but the characteristics of the good (licence) determining the outcome (profits from using the licences) are hidden to the firm, causing risks of adverse selection between high- and low-potential patents,
- hold ups, where behaviour before conclusion of contract cannot be determined, but behavior after conclusion of contract can be observed, causing incentives for the better-informed party (researchers) not to continue serving once the firms have paid for a license and invested in modern laboratory facilities,
- moral hazards, where behaviour before conclusion of contract cannot be determined, and behavior after conclusion of contract can only be observed to an inadequate extent, causing incentives for the better informed party to reduce its efforts.

In all cases, contractual incentives are needed to prevent opportunistic behavior by the better-informed party and encourage the worse informed party to invest, despite asymmetries in knowledge. Such incentives involve inclusion of the better-informed party in the future utilisation of licences (e.g. as a shareholder in spin-offs), risk premiums for the better-informed party, based on future market success, or signalling strategies by the better-informed party to build up a certain reputation as a fair contractual partner.

In 2002, the German government tried to institute incentive-compatible reforms of the IPR regulations for university researchers. In sharp contrast to the statutory IPR regime for industry, know-how produced at universities was, before 2002, in the sole possession of the respective scholar, who could therefore sign deals with industry contracts without violating any university laws. This even extended to the content of dissertations and theses, for instance masters' theses, as they are written under the academic supervision of a professor. However, masters' theses were considered in the 1990s to have their own copyright law (as do PhD theses, which are the sole possession of the author), and the intellectual property was considered to be held by the student. In many cases, this led to contracts between the professors and their students regarding the ownership of intellectual property contained in the theses. Problems arise in contract work, above all in engineering, when a firm, e.g. a car manufacturer, contracts work to a university institute that subdivides it into academic work packages, i.e. separate theses that address specific problems.

In February 2002, the privilege of professors was abolished and replaced by a regulation similar to that governing industry – inventions made at universities must be declared to the university, which then has to decide within a three-month period whether to make use of the invention or not. If the university makes use of it, the respective professor obtains a premium, if not, he may market the content of his invention himself, i.e. apply for patent protection. The basic idea was to follow the approach used by United States universities that generate income by selling off technology or triggering spin-offs.

The new situation has at least three very adverse results:

When universities and industrial firms cooperate, the legal status of any know-how developed is not entirely clear. The scholar cannot simply sign a contract by which he transfers all rights to inventions to the industrial partner, as was historically the case. Thus, any contract today has at least three parties, namely the partner from industry, the university and the scholar. This has reduced flexibility and increased the risk of disputes, due to changes in the general institutional arrangement.

Universities have a serious problem evaluating the potential of know-how produced in their respective institutes. To a large extent, these results relate to experience/credence characteristics. Thus, besides the inventor or developer, there has to be a competent expert ('supervisor') in place who is able to position the results in the market – be it a research or a business market. As a consequence, federal states have set up new institutions beyond the university – 'evaluation offices' – that are supposed to finance universities in the long run from income generated by selling off technologies. However, this has reduced the incentive of universities because only part of these funds are channelled back to them. As a consequence, the 'reward' side of the principal-agent problem remains unsolved.

Finally, such regulations are not incentive-compatible for university scholars. We assume that the professor or his network is able to evaluate the potential of an invention. If he were not, he would have left the knowledge to all those with an interest in it. Such knowledge would then constitute a public good, and the beneficiary of dissemination would be the general public. The rewards would be reflected in increased taxes and thus be beneficial to all – except in cases where the capacity for detecting and unveiling, evaluating and assessing, and, finally, producing and marketing these results does not reside outside the university. A more general problem then arises that remains unsolved under all institutional frameworks. In the first case, the scholar could be honest and declare all inventions to his university. If the university takes up the invention and protects all IPRs, he obtains a premium and the matter is closed. If the university turns down the invention, it is left to the scholar to exploit. If the university takes over the rights to the invention and fails to develop it, there is a risk that the scholar will sue the university for failing to exploit his invention. The rational scholar will therefore surrender any products of research that have no market potential to the university, or even flood the university with such products and cause a breakdown of the university's capacities. The one scenario is that the university takes ownership of intellectual property but finds it difficult to commercialise it, in which case the scholar has reduced his own marketing risk and could even file for compensation if the university is not sufficiently eager. Another scenario is that the university turns down the invention and it returns to the scholar, who has now learnt more about its market potential, thus profiting from reduced information asymmetries. In yet another scenario, he could keep interesting and high-potential inventions within his own research company that he runs with other individuals, making it very hard for the university to prove that he has been dishonest. The only solution lies in a screening procedure under which a self-selection system forces the scholar to disclose his knowledge of market potentials, i.e. a choice between fixed and variable components of participation.

In effect, this means that the new regulation generates additional institutional problems, due to existing knowledge asymmetries between universities and researchers, instead of solving the IPR problems that exist in academia-industry relationships.

2 Academic entrepreneurship and academia-business links

During the past few years, new science-driven sectors have emerged in which there are no clear-cut boundaries between basic science and applied product development, generating new opportunities for researchers at university and basic research institutes to establish their own businesses as spin-offs, spin-outs or start-ups. Public and private venture capital schemes have been created to support these activities.

Spin-offs, start-ups and networks in UK universities

Sir Douglas Hague from Templeton College, Oxford presented an overview of the current situation for academic entrepreneurship in the UK. In the UK, spin-offs are defined as companies set up to commercialise discoveries stemming directly from university research. University start-ups are also created by academic staff or students. However, these start-ups are not directly related to university research projects, but are based instead on the inherent knowledge and expertise of those individuals. Because spin-offs are specifically concerned with technology transfer, the offices set up by universities to oversee their creation are known as technology transfer offices (TTOs). The University Companies Association (UNICO), an association of TTOs, recently published detailed information about spin-offs. The UNICO-NUBS 2001 Survey on 'University Commercialisation Activities' was carried out for UNICO by Nottingham University Business School, and provides figures for 79 UK university institutions. The 'Higher Education-Business Interaction Survey, 2000–01' by the Higher Education Funding Council for England (HEFCE) provides similar information for about 160 UK institutions and pays more attention to start-ups than does the UNICO-NUBS study.

The UNICO-NUBS study shows that, between 1997 and 2001, 79 UK institutions spun off 554 businesses, 175 of them (35 per cent) being set up in 2001 alone. The HEFCE paper reports that there were 248 spin-offs in 2000–01 from its larger, but overlapping, sample. The rate of spin off was increasing until 2001 but, with the end of the high-tech and dot-com booms, it is likely that performance in 2002 was less good. The 175 UNICO businesses that were set up in 2001 came from 53 institutions, but 14 of them established more than five spin-offs and one more than ten. On average, therefore, the remaining 38 institutions established fewer than 2.5 businesses each. The UNICO survey shows that, in 2000, 140 US universities created an average of 1.45 spinouts each against 2.2 each for 79 UNICO respondents. What is more, the average research expenditure for each of these US universities was ten times the £8.9 million for the UK respondents. Given the relative size of the two countries and of their universities' research expenditures, British universities have no need to apologise for their performance.

The UNICO-NUBS survey provides information about the ways in which the 554 spin-offs created between 1996 and 2001 were financed. Venture Capital (VC) companies provided varying proportions of the equity capital raised by each of 136 spin-offs (24 per cent), but a large proportion of these funds went to more than 120 spin-off companies in only 6 universities, one of which established 25 spin-offs with VC support. And 64 per cent of respondents used no VC funding at all. Business angels provided differing amounts of finance for a further 92 spin-offs in only 22 universities (17 per cent of the total). As with VC companies, therefore, many UNICO-NUBS respondents did not use business angels. The UNICO report finds this 'surprising given the significant role that business angels are assumed to play in providing the seed finance necessary to develop promising ideas into business start-ups.'

The English University Challenge Competition, SMART awards and other government schemes were introduced – especially in Scotland – to give universities money they could use to move ahead scientific discoveries that were still at too early a stage to be safely financed by business angels or venture capitalists. The term 'Proof of Principle' is often applied to this phase of developing a discovery and will cover, for example, the research and development work intended to show that a process that works well in a laboratory can be operated on a commercial scale. The Scottish Proof-of Principle and Welsh Spinout programmes have a similar objective. Over the five-year period 1996–2001, as many as 59 universities (78 per cent of the respondents) received no University Challenge money at all. Such money went to 68 spin-offs (12 per cent of the total) in about a quarter of universities. This means that 17 institutions, or 22 per cent of the 76 of the respondents to this question, received University Challenge Fund money that they used to establish about one spin-off each. Joint Ventures provided finance for 35 companies (6 per cent). These were set up in conjunction with industrial partners, and usually resulted from joint research that led to new IP, or to know-how that could be exploited commercially. Again funding was heavily concentrated. Only 19 universities received any joint-venture support, establishing between one and five companies each, but this kind of finance can be used only if a research link exists, or can be established, with a company that has the resources to develop commercial products stemming from a discovery and to market them.

'Other' funds – including the capital or savings of founders, investments by their colleagues, families or friends and bank loans – financed 223 spin-offs in 41 per cent of institutions. This may seem a large proportion, though closer inspection might show that some of these financiers could also be classified as business angels. But it reinforces the point made above that there is apparently a financing gap at this very early stage where the amounts of money required can be rather small, but the number of potential borrowers can be quite substantial.

The UNICO-NUBS report ignores start-ups, but the HEFCE report gives figures showing that 69 were established by university staff in 2000–01 and 238 by graduates – a total of 307. Many start-ups in the UK receive no financial contribution from any university. Indeed, it is possible that no university knows of a particular company's existence, which is why the HEFCE figure of 307 start-ups in 2001 should be viewed as an underestimate. While this means there are no precise figures on the financing needs of start-ups, Philip Treleaven, Professor of Computing at University College London, has pointed out that IT start-ups may require no initial funding from a university. As little as £5,000 or £10,000 can finance a useful beginning and, as he puts it, 'most students can put their hands on this kind of amount'. Where greater funding is needed, venture capitalists are often avoided as being too 'greedy' for start-ups, but business angels can provide capital running to hundreds of thousands of pounds, and most ‘angels’ maintain close, continuing relationships with companies they help.

This conference paper supported the belief that a significant increase in the number of spin-offs is both necessary and feasible in the next phase of commercialising university research. If this is to happen, the innovative imagination of those formally employed in technology transfer by universities and the more entrepreneurial ventures of individuals will need to be emulated by many more. And, beyond that, universities will need to link themselves as positively as they can to the informal networks of support that are developing in wider communities outside.

Empirical findings from Germany on spatial patterns of research spin-offs

Alfred Spielkamp, University of Applied Research at Gelsenkirchen, presented a joint paper with Jürgen Egeln, Sandra Gottschalk and Christian Rammer from the Centre for European Economic Research (ZEW) in Mannheim. They analysed the spatial patterns of spin-offs from German universities and public research organisations, and asked whether geographical proximity to their incubator actually plays an important role for their locational decisions. Based on a representative survey of start-ups in knowledge-intensive German industries in the 1996–2000 period, they found that about 55 percent of all research spin-offs, i.e. start-ups founded by one or more person(s) that previously worked or are still working in a university or public research organisation, are located rather close to their incubator organisation, i.e. within a 25 km radius. However, their aggregated location pattern differs significantly from that of their incubators. Almost 50 per cent of all research spin-offs are located outside agglomeration centres and urban regions. At the same time, 80 percent of their incubators are located in agglomeration centres and urban regions. This balance can be regarded as a flow of knowledge from the centres to surrounding and peripheral areas.

The fact that a majority of spin-offs are still established in the same region as the incubator is not necessarily due to their deliberately choosing to be close to the scientific institution. Most of the incubators are located in highly attractive regions in terms of economic activity and infrastructure, i.e. in the cores of agglomeration centres or in urban areas. These are locations where knowledge-intensive companies find favourable conditions such as proximity to customers, a highly skilled workforce, high-tech infrastructure and excellent transport links. It can therefore be expected that spin-offs – as well as other companies active in research and knowledge-intensive industries – are attracted to locations of this kind. Disadvantages typical of agglomeration areas, such as high land prices, high rents, or high transport costs due to traffic congestion are generally less relevant for small businesses.

The results of this empirical study suggest that the locational behaviour of research spin-offs is demand-driven to a major extent. If the incubator’s location is less attractive as regards the local urban economy, spin-offs are likely to move away. However, if they have strong formal relations to public research institutions and rely heavily on highly qualified staff, they tend to stay in the incubator’s region, i.e. if they use the incubator’s infrastructure, if they contract research to public research institutions, or if they use public research as a source for training their employees. Spin-offs with lower needs for academic qualifications and a lower level of cooperation are more likely to leave their incubator's region. They typically locate in suburban districts with a thriving research environment e.g. in regions with public research laboratories.

Spin-offs in high-tech manufacturing, which generally have a natural science background, tend to rely on technological input from the research community as a 'push' factor, and locate rather close to their incubators, whereas service-oriented spin-offs that typically have an economics or business administration background are those most likely to move away. Since the latter are far greater in number than the former, spin-offs contribute to interregional and not only to intra-regional knowledge transfer. In the literature, however, analysis of spin-offs often focuses on high-tech manufacturing. This may explain the widespread view that spin-offs are a local phenomenon.

In summary, the role of 'pull' factors for the spatial allocation of public research spin-offs as well as other start-ups in knowledge-intensive industries should not be neglected. These factors appear have as much influence on locational decisions as 'push' factors, such as the human capital base and the regional intensity of science and research activity.

VC industry in Israel and academia-business linkages

Morris Teubal from the Hebrew University in Jerusalem reviewed experience in Israel, where new high-tech companies emerged during the 1990s with the help of a public venture capital (VC) programme. He showed that VC emergence was part of the reconfiguration of a pre-existing electronics industry involving large numbers of start-up companies as well as new and powerful links with global capital markets. The main conclusions and policy lessons related to the effectiveness of specific technology policies targeted to the VC sector. He also stressed the dominant influence of background conditions specific to Israel that effectively prevent such models being copied in the UK or Germany.

The main factors, events or sub-processes influencing the emergence process and subsequent development in Israel are:

(1) favourable background conditions;
(2) events in or features of the immediate pre-emergence period (1990–92)
(3) targeted policies directly triggering VC Emergence (1993–6/7) & Cumulativeness
(4) strong co-evolution of VC and start up companies;
(5) global capital market links through initial public offerings and mergers & acquisitions.

The pre-existent, military-dominated electronics industry – which also underwent significant restructuring during the second half of the 80s –, a coherent and important horizontal programme supporting corporate R&D, domestic stabilisation policies and liberalisation of the capital markets, and globalisation of capital markets for technology firms (through Nasdaq) all contributed to a favourable environment that facilitated VC emergence. They enabled the appropriate design of *Targeted* VC policies (the Yozma Program in Israel) and a cumulative process of VC emergence and development. Co-evolution of VC and start-up firms, mirroring supply-demand and user-producer interactions in young markets, was one important axis and probably a distinctive characteristic of the cumulative process in Israel.

Grosso Modo, the Israeli high-tech experience of the 1990s, seemed very similar to that of Silicon Valley (both during emergence and during the 'reconfiguration' of the 1980s and growth in the 1990s). The main difference was policy-based: in Silicon Valley, there was no horizontal R&D support programme, nor was there a targeted policy aimed at creating a venture capital industry. But there were similarities both in terms of success, and in terms of the importance of start up companies, VC, their co-evolution and links with Nasdaq.

Although there are similarities between Israel and Silicon Valley, more differences can be observed between Israel and other well-known high technology and software clusters, e.g. Cambridge or Bangalore. Cambridge was probably less successful than Israel, and this may be related to significant differences in policy, the 'intensity' of start-up and VC companies, the extent of their co-evolution, and the strength of their links to Nasdaq. While the degree of success in Bangalore is at least comparable to that of Israel (in many respects it may be greater), the following differences have been observed: the emergence of a new software industry rather than reconfiguration of a previously existing high-tech IT industry, a focus on 'services' rather than 'products' and R&D, led by large companies rather than by VC and start-up companies, and few linkages to Nasdaq.

Finally, a number of issues emerge from the Israeli experience that pertain both to policy and to the possibility of applying the Israeli model elsewhere. The first issue concerns the newly-gained insight that the VC industry does not arise in a vacuum. Targeted VC support should not be the central thrust of policy aimed at creating a high-tech industry. VC should be regarded – at least at the beginning – as a domestic, relatively non-traded 'service' that might be stimulated or triggered once a high-tech sector has come into being and attained a certain size. Secondly, the Israeli case suggests the importance of a mixture of policies, e.g. a horizontal policy creating favourable conditions in terms of innovation in the business sector in general, and a subsequent targeted policy aimed at the 'private support infrastructure' for such an R&D and high-tech sector. The initial programme's impact on the business sector helped to identify the economy's comparative advantage in innovation and high tech, and indirectly the specific 'needs' or priorities which a subsequent targeted programme (e.g. Yozma) could address. Building a portfolio of policies is not simple, but requires policymakers to adopt an evolutionary and systemic perspective involving varying degrees and forms of government intervention, depending on context, while simultaneously paying attention not only to incentives but also to institutions and organisational forms. This relates to the last point in the Israeli experience, namely the timing and design of Yozma (the 'targeted policy'). One essential step was policy experimentation prior to selection of an appropriate design, and policy learning based on closely following a series of business experiments in the new model for high-tech industries that seemed to be emerging from fundamentally changed conditions in the country's external environment.

Spanish experience with academia-business linkages

Javier Alfonso Gil from the Universita Autonoma de Madrid presented a joint paper with Antonia Sáez-Cala on the Spanish experience in fostering academia-business linkages. Compared to other OECD countries, the level of public and private R&D expenditure and staffing in Spain is noticeably lower. In general, universities have only weak ties to the private sector, and patents are only rarely requested. Research is highly concentrated in the regions of Madrid and Cataluna. Spain has therefore much to learn from other countries in the area of knowledge transfer. Despite some indications of institutional change, its public research system is still weighed down with an outdated institutional framework that is unable to respond adequately to the needs and requirements of modern science and technology. The disparity between public and private research is evident, prompting the conclusion that both financial and human resources should be more biased towards the private sector in the future. At present, Spanish firms are neither willing nor have the capacity to carry out the research necessary to participate in the most dynamic sectors of today's, and more importantly, of tomorrow's industry. However, besides improving the absorptive capacities of private firms, links need to be created between universities as the originators of knowledge and the entrepreneurial fabric of the economy as the natural transmitter of knowledge. These instruments must help create incentives for academic researchers. Transforming researchers into shareholders of their own firms or spin-offs will promote the search for ideas, as well as the dissemination and application of those ideas to the production system. To a partial extent at least, this would increase incentives throughout the researcher's academic career, in that their IPRs and eventual exploitation will lead to greater financial rewards for their work. An alternative solution to the problem is to create intermediate organisms acting as incubators for the development and consolidation of spin-offs in industrial fields where advanced knowledge is applied. The objective is to link academic knowledge to the industrial fabric, and to change the traditional institutional rigidity of the university. Since spin-offs focus on relatively new fields of knowledge, their industrial activities are submitted to a high degree of institutional, technical or financial uncertainty and risk. Consequently, survival rates are very low and – due to the high risks involved – access to funding is limited, even though investment returns may be high. It is still too early to appraise and evaluate Spanish experience with the creation of spin-offs. The positive note of the presentation is that the universities seem to be increasingly aware of the need to transfer knowledge to society and, consequently, there are groups within the institutions who are searching for ways to do this.

Empirical evidence on academia-business links in Italy

Francesco Lissoni from the Bocconi University in Milan presented research results on formal patterns of cooperation and technology transfer between academia and business in Italy. By analysing data on involvement in patents registered at the European Patent Office between 1978 and 2000, he identified the input of inventors, who were employed in 2000 as professors, researchers or lecturers at Italian universities. The objective was not to evaluate the contribution of the academic sector to patents in Italy, but to identify cooperation and networks between academia and private-sector companies. Initial results show a high level of fragmentation within the network, with the exception of more science-driven sectors like the chemical and electronics industries. Here, academic inventors play an important role, as they more often and more persistently cooperate with different stakeholders in academia and business. Thus, they are decisive nodes for the emergence of social knowledge networks. Further research will lead to a more precise picture of networks and intensity of cooperation, as well as to more information on central nodes and causes for their central role.

3 The technological dimension of academia-business links

Three presentations dealt with the influence of specific technologies on academia-business links and institutional solutions in different countries aimed at overcoming these challenges.

The case of biophotonics in Germany

Guido Benzler, a manager at Deloitte Consulting, and *Michael Kraus*, founder of Kraus Technology Consulting, discussed challenges for technology policies caused by uncertainties in current research results and applications in leading-edge technologies. Biophotonics is a new technological field requiring expert knowledge from both the life sciences and optics. According to the US National Science Foundation, Centre for Biophotonics (2002), 'Biophotonics is the science of generating and harnessing light (photons) to image, detect and manipulate biological materials. Biophotonics is used in *biology* to probe for molecular mechanisms, function and structure. It is used in *medicine* to study tissue and blood at the macro (large-scale) and micro (very small scale) organism level to detect, diagnose and treat diseases in a way that are non-invasive to the body'. Considering this need for connectedness between different technologies, biophotonics is used as an example of 'integrating technologies' requiring interdisciplinary knowledge transfers and cooperation to exploit their commercial potential. The specific challenges caused by these types of technologies compared to conventional industrial sectors and technologies are summarised in the table on the next page.

Evaluating a large-scale research and development program in Japan

Philip Shapira from the Georgia Institute of Technology presented a joint paper with *Ryuzu Furukawa* and introduced a transnational dimension to the debate. The Japanese government has tried to achieve a higher level of performance measurement and evaluation in its science and technology policy by inviting international evaluation researchers to do external evaluations of Japanese R&D programs. This research has revealed the typical strengths and weaknesses of large-scale R&D programs in Japan. On the one hand, it actually improved research capabilities and prestige for the participating companies. On the other hand, universities and private-sector companies not participating also acquired a strong role in developing new capabilities. Compared to other countries, Japanese programmes are less concerned with inter-organisational innovations, and creating capabilities and incentives for linkages between universities and private companies has only recently been seen as an important element of R&D

Summary of relevant factors in the development of technologies

	Industry branches	Key technologies	Integrating technologies
Example	Steel, coal, mining, farming, chemistry, construction industry…	Biotechnology, laser, nano, micro, superconductivity…	Biophotonics, neuroinformatics, nanobiotechnology…
Characteristic	Application of established methods, materials and mind-sets, low R&D activity, large number of workers, mass production, tight price corridor, international competition	Specialised expert groups with high technological skills to harness the challenges of the individual technology	Combination of two or more key technologies, successful application based on the expertise of at least two experts from different technology fields
Success factors, challenges	Efficiency, business processes, labour costs, tax issues	Academic fortune, teamwork with technology experts	Deep understanding of the achievements and questions within the respective other technology, common language, availability of experts from different technologies
Evaluation issues	Mainly economic issues, ROI, market share, sales methods	Publications, patents, conferences, functional models, proof-of-principle	Density of technology patterns, capabilities to network, knowledge sharing, application of publications and patents, understanding of customers' needs
Business issues	Concentration on core competencies, strong international competition	Concentration on core competencies, market technology driven, key applications still open	Open-minded policy required, new products may require handling non-core competencies, product may be within a totally new market, market driven by needs
R&D funding scheme	Not applicable, funding only in the case of economic crisis	Classical project support	Financing of network structures, stimulating joint ventures, reducing classical project support that focused on only one technology

strategies. The study showed the relevance of cultural specificities, as performance-based allocation of public financial support is still in its early stages, and for many researchers the change in evaluation routines to more advanced methods is a new and challenging experience. However, the emergence of new journals and agencies for evaluation illustrate the increasing relevance of this field and the experience and methods of other countries for the Japanese science and technology system.

A matrix of instruments and needs of technology for evaluating innovation policies

Riccardo Cappellin from the 'Tor Vergata' University in Rome presented a three-dimensional concept for evaluating innovation policies from the demand-side perspective of small and medium-sized enterprises (SMEs) as addressees of innovation policies. The three dimensions refer to (1) industries (from science-based to traditional industries),

(2) firms (from Schumpeterian to marginal firms) and (3) regions (from metropolitan to peripheral regions). For all three dimensions, it is possible to identify specific factors influencing the emergence of innovation capacities. These factors indicate the needs for support from innovation policies. By scoring these needs according to the different types for each dimension – e.g. a Schumpeterian firm using science-based technologies in high-tech clusters – a matrix was created with needs along the rows and instruments along the columns. As a result, each innovation policy instrument was scored according to its contribution to satisfying the needs of SMEs. Representatives from SMEs gave scores for needs and instruments. This INT matrix indicated complementarities and trade-offs between different instruments in innovation policy, as instruments have different priorities in different industries, firms and regions, and each problem has to be tackled by different types of innovation instruments and intermediaries. Thus, the two major characteristics of the 'INT Matrix' model were:

- the adoption of a 'demand led' rather than a 'supply push' approach. That has led to analysis being focused on the characteristics and needs of innovation by various regions, sectors and firms, rather than on surveying the potentials and problems of existing technology transfer intermediaries.
- the identification of an intermediate step between analysing the characteristics of specific countries and designing innovation policy instruments. That has led to a focus on relationships between the specific needs ('demand') of various industries/technologies, firms and regions, and the relative effectiveness of the various types of innovation policy instruments ('supply').

It must be emphasised that the 'INT Matrix' model does not propose a particular solution, but rather a methodology that needs to be handled with care and adapted to specific circumstances and problems. It does not deliver a unique best solution for many heterogeneous cases, but is intended rather to help policymakers disentangle the various dimensions, variables and parameters to be considered and estimated.

4 The regional dimension of academia-business links

The conference ended with a discussion of the regional environment of new academia-business links. There has been increasing interest on the part of policymakers in creating new incentives for universities and public research organisations to intensify cooperation with regional companies and organisations, since geographical proximity has been identified as an important factor for improving the transfer and dissemination of new – tacit – knowledge.

The micro-and meso-level of territorial knowledge systems resulting from university-business interactions

Paul Benneworth from the Centre for Urban and Regional Development Studies at Newcastle University presented a joint paper with *Stuart Dawley* from the same institute. They focused on the dynamic interactions between universities and SMEs that lead to different kinds of expertise and options for cooperation for different companies, depending on their respective capacities for innovation. This means that improvement in universities' outreach activities can be regarded as a meso-scale change as long as it can be demonstrated that new capacities have been created. Their key finding relates to the issue of capacities and activities in universities. Particular activities take place and draw on capacities within universities, but not all capacities are necessarily used at any one point in time, and the 'service bundles' offered to firms by universities are pulled together from all the capacities that universities have. Capacities are generated, developed and expanded through interaction with particular key firms, and once expanded, are more widely available to other firms.

A key point is that this capacity – being latent – is not always immediately obvious, so that simply engaging in an activity is not sufficient for universities. It is the capacity reflected in such activities that is important. In particular, the development of that capacity is important in terms of increasing the openness of the universities to firms at decreasing levels of sophistication. Thus, in developing a nuanced understanding of novel institutions for promoting university commercialisation, this research suggests that what is important is not the institutions themselves per se, but the capacity they represent. Moreover, universities may require multiple responses to ensure that firms at all levels of sophistication can access the capacities within the universities; possible responses are suggested in the table opposite.

Types of 'response' required by universities to provide technology transfer opportunities to firms at each level of sophistication

	Reason for dealing with university	Development of relationship with university	How the university can facilitate relationship
Expert	Shaping the university's strategic decisions to the firm's own benefit	Strongly interpersonal at high level: e.g. between MD and VC.	A willingness to engage with local firms
Experienced	Accessing complementary research activities and exploiting low overhead rates	Personal trust in research capacity of department, contractual relationship controlling funds and IP.	An IP management framework that allows collaboration; academics given freedom to explore opportunities
Inexperienced	Accessing external research funds to shore up own internal R&D activities	Someone has a plan for a big research bid, and the firm is approached to take part.	A research contracts unit to pull together big partnership bids and ensure the university has a range of bids
	Consultancy services	One-off service or membership of specialist unit	Specialist consultancy units
Novice	Getting the advice and credibility of an expert in writing a funding bid	Contact 'expert' in response to recommendation from friendly adviser	Rewarding individuals who give ad-hoc support to novices

The rise of transboundary organisations in regional innovation systems

Phil Cooke from Cardiff University expanded the analysis of university-business interactions to additional organisations created to overcome barriers between universities and business. Systemic linkages between R&D organisations, firms and other regional actors are seen as a basic prerequisite for the effective utilisation of the knowledge base. Such utilisation involves the generation, examination and commercial exploitation of knowledge, and interactions between different players from academia and/or business are needed in all three stages. However, only a few interactions have actually emerged, due to uncertainties and cognitive barriers between representatives of the different types of organisations. Transboundary organisations will help to overcome these barriers to interaction and cooperation, but many new organisations like the Regional Development Agencies in the UK or Germany have had little success so far. Phil Cooke presented several examples of best practice from different countries that provide a suitable response to different challenges to regional innovation systems – e.g. Regional Science Councils in Scotland as an approach for knowledge generation and examination, integrated technology incubators and centres in France and Israel to improve the exploitation of new knowledge – to illustrate the potential of suitably designed and well-focused organisational approaches.

The transregional dimension of academia-business linkages

Finally, Rüdiger Wink from the University of Birmingham discussed the specific challenges of a transregional dimension of academia-business linkages. Many EU programmes and national initiatives in European countries were aimed at improving cooperation beyond regional boundaries. The term 'transregional' refers to linkages between areas in different countries that are not neighbouring regions. This means that simple spatial spill-over effects cannot be expected. Cooperation can have positive impacts when the codes of communication in the different regions can be made accessible to stakeholders from other regions. In practice, only few systemic transregional linkages can be observed. The presentation therefore discussed the prerequisites for successful political programmes. In particular, the need for strategic focusing was stressed, given that many political programmes in regions and single countries are mere copies of similar initiatives in other regions (countries). The strategic focus requires (1) a discussion of actual objectives, which can be achieved by fostering transregional linkages of academia and business, e.g. affected sectors and technologies, regional competitiveness, necessary additional regional factors, (2) the operationalisation of this objective, taking into account the actual possibilities for, and limits to academia-business linkages, e.g. numbers of transregional patents, publications, or formal cooperation, (3) the selection of suitable instruments, e.g. appointments at universities, financial support of research contracts, franchising systems or alumni networks, and (4) the selection of evaluation criteria and methods. However, one should not overestimate the number of regions that might be positively affected by transregional knowledge flows, and the impact these flows can produce. Nevertheless, the internationalisation of science and science-driven sectors will further increase the role of these options for cooperation.

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