The Role of TICs in Rejuvenating British Industry:

Submission to House of Commons Committee on Science and Technology Enquiry on Technology Innovation Centres

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Summary

Since 2007, we have been working on a project to examine how academic research in the physical sciences could be commercialised more effectively. This work has entailed an extensive examination of Germany's Fraunhofer Institutes and other organisational models on which the TIC concept might be based. It has included visits to leading R&D organisations in Europe, the United States and Far East, as well as public and private sector organisations in the UK. This submission summarises the key findings and makes detailed proposals for how TICs should be selected, directed, managed and funded.

Background

The project has been undertaken as part of the EPSRC funded Cambridge Integrated Knowledge Centre for Macro-Molecular Materials. The aim of the IKC is to accelerate the commercialisation of a group of plastic electronics and photonics projects in the Cavendish Laboratory and Electrical Engineering Division at the University of Cambridge by attracting industry partners and adopting a more "managed" approach to the portfolio[1].

The CBR project has two special features:

- Tracking the IKC technology projects in real time to examine how strategies and expectations evolve, and identify barriers to commercialisation,
- A parallel programme of visits to other "role model" laboratories and organisations in the US, continental Europe, Taiwan and Korea in order to compare their approach with the IKC and identify organisational models and policies of relevance to the UK

This submission and its conclusions are based on this work, which included a high level policy symposium CBR organised in November 2008 with senior speakers from the Fraunhofer-Gesellschaft, IMEC, DIUS, EPSRC, TSB and MOD. It also builds on a number of other innovation research projects undertaken by the authors and other members of the CBR, including research undertaken in its capacity as co-host of the UK Innovation Research Centre (UK~IRC), funded by ESRC, BIS, TSB and NESTA. Finally, it draws upon David Connell's experience as founding Chief Executive of an early stage venture capital fund (TTP Ventures), member of the management team of one of Cambridge's most successful technology "consultancies" (The Technology Partnership plc, now TTP Group plc), and fifteen years experience of providing consulting advice to large corporations on R&D management, technology exploitation and new ventures.

This research has included visits to three Fraunhofer Institutes in Germany and one in the United States. Visits to other "Intermediate R&D Organisations" include the Industrial Technology Research Institute (ITRI) in Taiwan, the Electronics and Telecommunications Research Institute (ETRI) in Korea, The Holst Centre in the Netherlands, the Inter-University Micro Electronics Centre (IMEC) in Belgium and the Printable Electronics Centre (PETEC) in

[1] See http://www-g.eng.cam.ac.uk/CIKC/ (EPSRC grant reference EP/EO236141/1)

Sedgefield, County Durham. Our visits to these institutions have been supplemented by interviews with senior people from industry, government agencies and academia in their host nations to provide insight into their operation and level of success. Fieldwork in Japan will take place during early December.

This project is still "work in progress". Details of some of the results have been published in a working paper[2] and this formed the basis of an input to the Hauser Enquiry earlier this year.

Findings: I. Exploitation of Academic R&D

Our research has shown that there are major problems in accelerating commercialisation in conventional university research settings.

- Most externally funded research projects in universities are undertaken by teams staffed by PhD students and post-docs who tend to move on quickly. As a result it is very hard to retain competence in depth or build the core technology team required to create a spin out business. This is exacerbated by the dominance of short term grants and employment contracts

- The time that must be devoted to writing publications, teaching, supervisions and giving papers at academic conferences means that R&D during a pre-venture stage can only be advanced in fits and starts

- IP is often not managed throughout a project, but is typically only thought about at the point of considering a spin-out or negotiating with large users who may wish to commercialise the technology. Past leakages of various kinds and competitor positions may only then become apparent. The problem is particularly acute for the long lead time technologies which typify much academic research as there may be an accumulation of IP over successive projects involving many different individuals attached to a given research group. Failure to protect early inventions (or where appropriate to publish to ensure "freedom to operate") can compromise commercialisation opportunities that may arise several years later.

- Pressure to collaborate with industry, coupled with changes in personnel, means that exploitation rights are not always properly thought through or managed over the long term in the way that a commercial organisation or Intermediate Research Organisation such as a Fraunhofer Institute would. This can cause conflicts to emerge later that can restrict the potential for spin-off or effective licensing and contract research developments with potential commercial funders.

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[2] Mina, A, Connell, D. and Hughes, A. (2009), *Models of Technology Development in Intermediate Research Organisations*, CBR Working Paper No. 396, Centre for Business Research, University of Cambridge: Cambridge.

- It is very difficult to accelerate the pace of R&D prior to the stage when a technology becomes ripe for exploitation, for example by increasing the size and commercial orientation of the R&D team during the pre-venture stage. As a result any competitive advantage can be eroded at this critical stage.

- Universities are not normally equipped with the expertise or resources to take technologies to the demonstrator stage required to attract investment or customer interest

- University academics lack the time and experience to manage a portfolio of projects using stage gate approaches to manage risk and progressively focus funding on the projects which are most promising from a commercial perspective

It is difficult to see how these problems could be addressed within a conventional UK university research setting.

These issues are compounded in the UK because in many areas of technology the natural industry collaborators are foreign companies with little inclination to commercialise in the UK. Spin-outs, commercialisation partnerships with smaller UK based companies, and a systematic attempt to encourage the attraction of inward investment must therefore play a disproportionate role if there is to be significant economic benefit to the UK[3]. Furthermore, SMEs often lack the funding or resources to engage with university academics, especially given the long lead times to commercialisation that is often involved.[4]

This interpretation is reinforced by research on the business models pursued by the most successful companies within the Cambridge Cluster.[5] This concludes that very few of its most successful science and technology companies – at least in the physical and engineering sciences - have their origins in academic intellectual property and that the importance of direct university spin-offs has been significantly oversold.[6] In particular, the city's technology "consultancies", described later, have been a more important source of successful spin-offs in terms of jobs created.

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[3] Inward investment in science and technology industries is, of course, often itself associated with the acquisition of an existing company.

[4] In a recent major parallel set of CBR surveys of academics and businesses funded by the ESRC the most important and frequently cited factor which businesses identified as constraining their interactions with the science base was their own lack of internal resources. Academics cited lack of time. Neither rated differences in culture or time scales as a significant factor. See *University-Industry Knowledge Exchange: Demand Pull, Supply Push and the Public Space Role of Higher Education Institutions in the UK Regions. (www.cbr.cam.ac.uk/research/programme1/project1-17.htm)*

[5] Connell, D. and Probert, J. (2010), *Exploding the Myths of UK Innovation Policy: How 'Soft Companies' and R&D Contracts for Customers Drive the Growth of the Hi-Tech Economy*, Research Commissioned on Behalf of the East of England Science and Industry Council by the East of England Development Agency. CBR, University of Cambridge.

[6] See also Hughes, A. (2008), *'Innovation policy as cargo cult: Myth and reality in knowledge-led productivity growth'*, in Bessant, J. and Venables, T. (eds), Creating Wealth from Knowledge. Meeting the innovation challenge, Edward Elgar, Cheltenham and CBR/PACEC(2009), *Evaluation of the Effectiveness and Role of HEFCE/OSI Third Stream Funding: Culture Change and Embedding Capacity in the Higher Education Sector Toward Greater Economic Impact*, A report to HEFCE by PACEC and the Centre for Business Research, University of Cambridge.

This research also shows that R&D contracts with customers and the "soft start-up"[7] model has played the dominant role in funding these successful companies through their early stages, with venture capital playing a less significant, or later stage, role than the conventional wisdom would imply. The report argues also that multi-partner R&D collaborations, the dominant model in UK Government and EU R&D funding for companies, are of little relevance to early stage firms and other SMEs.[8] Lead customer contracts from private and public sector customers usually provide a much better mechanism for directing and funding their technology development.

Our international comparisons have revealed a variety of ways in which other countries' innovation systems address these problems and designed institutions that are better equipped to exploit long lead time commercialisation opportunities for national benefit.

Findings: II. Institutional Models

Private Sector Technology Consultancies

The R&D organisations with the most relevant track record of turning R&D projects into product businesses in the UK are to be found in the private sector, and comprise the Cambridge technology "consultancies" (Cambridge Consultants, TTP Group plc, PA Technology and Sagentia as well as smaller companies focused on specific sectors). The term "consultancy" is really a misnomer and relates more to their revenue model (fees), than the kinds of outputs produced. These are predominantly developed products and specialised manufacturing and test equipment for their customers, rather than reports or advice.

Individually the four main firms are of similar size to the Fraunhofer Institutes and they perform a very similar role for their private sector customers. However, this has been almost entirely without Government or EU funding of any kind (the Fraunhofer Institutes are roughly 50% Government and EU funded), and they typically earn 60-70% of revenues from exports (c.f. 10% or less in the case of the Fraunhofer Institutes). Furthermore, the rate at which jobs have been generated in product spin outs is significantly better than the Fraunhofer-Gesellschaft and they have had bigger, and more sustained, successes.

The Cambridge consultancy cluster is not mirrored anywhere else worldwide and is an important national economic asset.[9] Only the larger Cambridge consultancies are able to invest significantly in technology development on their own account and the relatively short term focus of the consulting model militates against this. Nevertheless, they have been able to harvest IP and expertise developed over the years to spin off many successful product

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[7] A "soft company" is a science or technology based company whose business model is to provide R&D based services (e.g. technical consulting, contract R&D) and which draws on its expertise and/or proprietary technologies to provide bespoke offerings for a range of customers and applications. A "soft start-up" is a company that uses this model in whole or in part to finance its early development, thereby reducing or avoiding entirely the need for external equity investment. Soft start-ups may continue to adopt this model and remain a service business, or they may transition to a "harder" business model based around standard proprietary products.

[8] *Exploding the Myths of UK Innovation Policy,* op. Cit.

[9] There are individual organisations with some similarities in many countries.

businesses. In one or two cases very long term investments in platform technologies have been made alongside commercial contracts for specific applications.[10]

The trigger for the creation of a product spin-off has often been the loss of a major customer, bringing both opportunity (through, for example, the chance to acquire unwanted IP) and incentive.

The four largest Cambridge consultancies employ over 1,000 people between then, but have created product spin-off business employing over 5,000 people, including two of Cambridge's largest and most successful companies, Domino Printing Sciences and Cambridge Silicon Radio. The Cambridge consultancies are some of the most effective organisations we have seen anywhere in developing and commercialising new technology. So in considering how to exploit the academic science base better, we would do well to learn from their successes. In later sections we draw upon aspects of this private sector model that can be borrowed in designing public sector subsidised interventions.

The Fraunhofer Model

The operation of the Fraunhofer Model is described in our working paper.[11]Its principal advantage over the private sector consultancy model is the core public sector funding that Institutes receive. This enables them to invest in long lead time technologies and supporting equipment where it is more difficult to attract private sector funding. This in turn helps them create the technology platforms around which commercial R&D contracts can later be sold.

Of the Fraunhofer Laboratories we have visited during the research, the Fraunhofer Institute for Photonic Microsystems (IPMS) in Dresden illustrates best the kind of role we believe such organisations could play in the UK. Although it is possible that its position in the old East Germany has brought it particularly high levels of public sector funding. In technology terms IPMS is also a good comparator to the Cambridge University Integrated Knowledge Centre in Macromolecular Materials, whose EPSRC grant provided most of the funding for our research.

IPMS was founded in 1992 around a core team of 100 people from one of the GDR Academy of Science's Laboratories in Dresden, home of the DDR's large, but uncompetitive semiconductor industry.

It is important to understand the relationship between Fraunhofer Institutes and academia. They are not university institutions and are managed, directed, administered and funded entirely outside the university system. Their role and modus operandi is very different. A close relationship with a local university is important, but this is subservient to their role as developers of technology for their industrial clients and the level of interaction with academia is much smaller than sometimes believed. Today IPMS has some 200 permanent staff with a further 25 doctoral students and 25 masters students from related universities. Two of IPMS's directors hold chairs at the Technical University of Dresden.

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[10] For examples of how this has worked in practice, see Page 26, *Exploding the Myths of UK Innovation Policy, op. Cit.*

[11] Op cit.

This level of interaction with academia is typical of other similar Fraunhofer Institutes, with roughly one in a hundred of their 17000 permanent staff holding university positions simultaneously[12].

IPMS's 2009 revenue budget was $24m comprising $7m from core government funding, $7m from public projects (contracts, grants etc) and $10m from bilateral contracts with industry, license revenues etc. The Fraunhofer funding model uses a formula for the amount of core funding provided each year which is carefully designed to encourage revenues from bilateral industry contracts at between 25 and 55 per cent of the total[13].

In addition to the core funding for operating expenditures, capital investments at Fraunhofer Institutes are also funded by government on a case by case basis. IPMS has benefitted greatly from EU, Federal and Länder investments over the last five years. This has enabled it to acquire two significant clean room facilities and specialised processing equipment at a total cost of some €60m. One is for producing CMOS based microelectronic mechanical systems (MEMS) and micro opto-electronic mechanical systems (MOEMS) and the second is for OLED based products - lighting, organic solar cells and OLED-on-CMOS devices. The latter was originally built as the Dresden manufacturing plant of Micro-Emissive Displays, an Edinburgh based venture capital and AIM funded company. IPMS acquired this facility when MED went into administration in 2008.[14]

Both clean room facilities are operated around the clock on three shifts, five days a week. They have dedicated process management teams through whom research scientists must work to get experiments designed and run[15]. Both facilities can produce devices at pilot or small volume production scale, although there is considerable sensitivity amongst Fraunhofer management to conflicts of interest; they stress that these facilities would not (and cannot) be used to compete with existing German or European companies. It is difficult to see how a comparable style of operation could ever be achieved within a UK university environment.

The primary role of all Fraunhofer Institutes is to support German companies, including SMEs, without competing with them. In each case they aim to deliver fully developed products and if necessary the process equipment to manufacture them. In some cases they can also undertake pilot scale manufacturing on Fraunhofer Institute equipment and even full scale manufacturing for niche products where no fully commercial facilities are available This contrasts strongly with the role of universities which are limited to developing very basic "proof of concept"

[12] On appointment, the Executive Director of a Fraunhofer Institute is also simultaneously appointed as a professor at the university with which it is twinned. It should be noted also that it is rare for a Professor of Engineering in Germany not to have experience of working in industry first.

[13] New Institutes typically start with 20-30 people, sometimes as a spin-off from another institute, or by acquisition of another organisation. The level of core funding is usually guaranteed for 6 years initially on a gradually reducing basis as commercial contracts are expected to be won. After this the amount of core funding an institute receives is calculated according to a formula linked to its success in winning contracts. In the case of IPMS, the start up team was larger – around 90 people – and the transition time was a little longer.

[14] Dresden is also the home of the manufacturing facility of Plastic Logic, the VC backed spin-out from the University of Cambridge, though this is not co-located with IPMS and the two organisations have not collaborated on R&D projects.

[15] This compares with the typical UK university arrangement where students use the equipment themselves, with minimal specialist technical support

technology demonstrators[16]. Professor Lakner, the Executive Director of IPMS, stresses "*the difference between a demonstrator which may show that a product is feasible, but without meeting a customer's full specification* and *a prototype which must meet full specification without meeting lifetime, yield and cost targets"*. The Fraunhofer Institutes go well beyond the prototype stage to manufacturable product, just like the Cambridge consultancies.

There are significant differences between Fraunhofer Institutes in their mode of operation. IPMS typically works on product developments that are five to seven (or more) years from market and it is characterised by its industrial investment in capital intensive process technologies. Some are closer to market and more comparable with the Cambridge consultancies.

The most comparable facility to IPMS in the UK is the Printed Electronics Centre (PETEC) in Sedgefield. PETEC has had comparable levels of government investment to IPMS, but is inconveniently located for overseas customers and is geographically distant from major academic centres of materials and electronics technology.

Whilst IPMS has yet to demonstrate that it can spin-out substantial product businesses this is only one indicator of success. The level of engagement from (predominantly) German industry suggests it is a successful organisation in broader terms. Some Institutes seem to have a less good reputation and have probably suffered from low staff turnover and the gradual decline in the relevance of R&D programmes to which all privately and publicly funded laboratories are prone without regular review and rejuvenation.

The most publicised success of any of the Fraunhofer Institutes in commercialising technology on its own account relates to the MP3 standard. This was developed by the Fraunhofer Institute for Integrated circuits, based in Erlangen, and has generated tens of millions of Euros for the Institute in licence revenues. A good deal of effort has been devoted in recent years to encouraging the establishment of spin-off companies. Some 150 spin off companies have so far been created, though most seem still to be quite small and it is still too soon to evaluate how successful this activity has been[17].

Within the Fraunhofer system there have historically been certain aspects of the model, notably levels of pay and other incentives, as well as attitudes towards personal risk taking, which might have reduced their effectiveness in commercialising technology on their own account. If replicated in a UK context, the need to attract and retain the best people will be cardinal. This is particularly true in relation to creating economic value through that part of their activity concerned with spin-out businesses.

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[16] Producing technology demonstrators at the level needed to interest potential investors in spin-off companies and commercial partners is very challenging within the academic environment, even with policies designed to assist this process.

[17] The most successful "exit" so far seems to have been the sale to Dolby for $250m of an MP3 related company formed with a Swedish partner.

Other Intermediate R&D Institutes

In terms of economic impact, two of the most interesting institutions we have visited are the Industrial Technology Research Institute in Taiwan and IMEC in Louvain. We focus on the former here.[18] ITRI was instrumental in building the service based semiconductor industry in Taiwan, of which the Taiwan Semiconductor Manufacturing Company (TSMC) is the key element.[19] In 2009 the Taiwanese semiconductor industry had revenues of $39 billion and was the world's largest in terms of manufacturing. Its investment in semiconductor manufacturing has enabled many other companies to become established at other points in the supply chain. However, it should be noted that this was a "catch up" strategy involving licensing in existing semiconductor manufacturing technologies from western companies. Insofar as strategy is concerned with spin outs it is also important to note that the spin out performance of ITRI has not been central to its role in recent years. This is in part a reflection of the growing strength of Taiwan's companies and their use of strategies less dependent on government funded R&D to move into major new areas of business, like LCD displays. The central lesson from the ITRI model is the strategic creation of a central capacity to develop major businesses located in Taiwan.

A key part of ITRI's role in strategic capacity building[20] has been in training. 160,000 alumni have graduated from ITRI, with more than 140,000 of them currently employed in the business community. More than 5,000 work in Hsinchu Science Park, in which ITRI is based, serving in mid to high level management positions. 60 of ITRI's alumni are Chief Executives of Taiwanese corporations. The expertise built up through on-the-job training in technology development and exploitation in an organisation like ITRI is of course very different to that acquired in a university research role.

Finally, we would point also to one further interesting model – the Computer Aided Design Centre created in the early 1970s in Cambridge. This was largely Government funded with some industrial contracts. It was not part of the University of Cambridge, although there was an active 3-D modelling group at the University's Computer Laboratory. The CAD Centre went through some difficult times and many changes, including privatisation and flotation. Today it has transmogrified into AVEVAs the world's leading engineering IT software provider to the plant, power and marine industries, employing over 600 people. In addition, some of CAD Centre's early staff went on separately to found a succession of very successful software companies.[21]

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[18] IMEC's focus is on semiconductor processing. This makes it unique in Europe. Because of the huge investments in R&D and capital expenditure entailed in developing next generation process technology, the large companies involved are prepared to collaborate in a major way. A similar organisation in the US is the Albany Nano-technology Complex; its predecessor Sematech now has an international customer base. This approach is particularly appropriate where large players in mature markets are willing to co-invest on the scale and in the collaborative way necessary. For further discussion see Mina, A, Connell, D. and Hughes, A. (2009) Models of Technology Development in Intermediate Research Organisations, CBR Working Paper No. 396, Centre for Business Research, University of Cambridge, Cambridge. (www.cbr.cam.ac.uk/pdf/WP396.pdf).

[19] TSMC manufactures semiconductors for development and marketing companies like Cambridge Silicon Radio. It has enabled a whole new business model, that of the fables semiconductor business.

[20] See Models of Technology Development in Intermediate Research Organisations, **op.cit.**

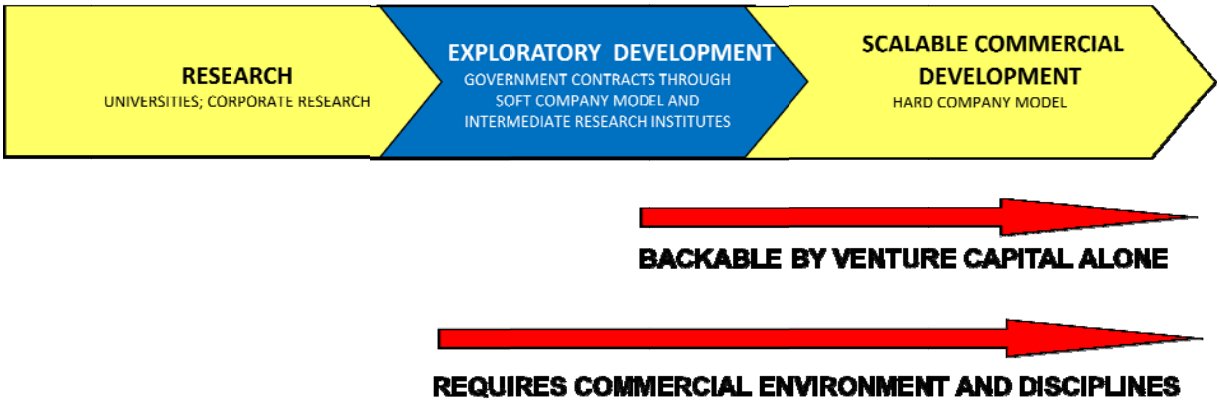
[21] See Case Study 9, page 50 in *"Exploding the Myths of UK Innovation Policy*, op. Cit.

Conclusions and Recommendations

Fraunhofer Institutes and other intermediate R&D laboratories have three key features which contribute to the role they play in technology exploitation: long-term government support through core funding and capital investment; their focus on mission oriented development rather than research and academic publications; and engagement with real customer innovation needs with significant R&D funding from lead customers. These include procurement contracts from government agencies.

Experience from the Cambridge cluster shows that the role played by lead customers in defining needs, funding technology development and trialling prototypes is crucial to successful technology exploitation. In the US government has played a key role in the process, through the £2 billion a year SBIR programme and other innovation procurement programmes.[22] Indeed, the vast majority of US government funding for R&D in companies is based on the procurement contract model as opposed to the multi-partner collaborative model involving companies and universities favoured in the UK[23]. In contrast in the UK, Government has found it far more difficult to encourage spending departments to place R&D contracts with companies.[24]

Exhibit 1 Policies for Translating Long Lead Time Technologies into Commercial Businesses



In deciding how much money to commit to Technology Innovation Centres, it is therefore important to consider what could be achieved through a complementary policy of increased innovation procurement from private sector companies. Both policies have the potential to bridge the gap between academic science and commercial markets illustrated in Exhibit 1. The former plays a dominant role in the US, the latter in Germany, though even the German Fraunhofer model depends for its success partly on Institutes being able to win R&D contracts from customers in the public sector as well as the private sector.

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[22] Connell, D. (2006), *'Secrets' of the world's largest seed capital fund: How the United States Government Uses its Small Business Innovation Research (SBIR) Programme and Procurement Budgets to Support Small Technology Firms*, Centre for Business Research, University of Cambridge, Cambridge.

[23] Lead contractors in the US may well use small companies or academics as subcontractors, but this is not generally prescribed a priori by government agencies.

[24] After two false starts the UK's misnamed Small Business Research Initiative is running successfully, but at a still very small level, at around £25 million a year.

Of these two complementary policies, we would place at least as much emphasis on expanding government funding for innovation procurement contracts to capitalise on the successful "soft company" model exhibited in the Cambridge context (and elsewhere) and enable the private sector to play the dominant role in technology development.[25] The funding and endorsement from lead customers this brings would also make it easier for entrepreneurs to grow their businesses more aggressively when the time is right, with funding from venture capital firms if needed.[26]. As indicated this would also support UK TICs created on the Fraunhofer model where this approach makes sense.

Experience of UK Faraday Centres and the more recent network of Micro and Nanotechnology facilities suggests that past UK attempts to create "innovation centres" have suffered from a poor understanding of success factors and inadequate specification of the model, coupled with its subsequent dilution to try to satisfy individual regional agendas on a restricted budget.

Nevertheless, we believe that TIC's based on a modified Fraunhofer model could have an important role to play for long lead time technologies where there is no conflict with an existing commercial business. [27]

Their objectives should be to undertake mission driven R&D leading to the creation of commercial products and processes, and through this activity to train scientists and engineers in both the technical and management disciplines involved. In time this should enable TICs to generate revenues from contract R&D for customers, licences and spin-offs.

It should be emphasised that this will require a very different style of operation to a university laboratory, with very different management philosophies. Whatever the process involved in the identification and selection of TICs, and while collaborative university and industry initiatives will be welcomed, it is essential that TICs have the independence and governance, management and incentive structures needed to deliver this mission driven, and strictly commercial orientation.

We recommend that:

- TIC's should be focused on a small group of related long lead-time technologies with engineering support. These should normally be newly emerging areas of technology with significant potential commercial impact but a scarcity of expertise internationally. A single, high risk area of technology is probably too narrow as it would inhibit comparison with other technologies and possibly prevent rational resource allocation within a TIC.

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[25] See also submission to House of Lords Committee on Science and Technology on this subject by David Connell, December 2010.

[26] Data on returns from the British and European Venture Capital Associations show that average returns on early stage investments in the UK and European technology sectors are inadequate to attract pension funds and other investors. Importantly, this is a long term problem, not a feature of the current economic climate. Significant complementary public sector support, as in the US, is therefore required to increase participation and procurement innovation contracts would be a way of helping to achieve this.

[27] The choice should be informed by a systematic strategic analysis as advocated by the Council for Science and Technology in their Report *Strategic Decision Making for Technology Policy* (2007) (www.bis.gov.uk/assets/bispartners/cst/docs/files/whats-new/07-1618-strategic-decision-making-technology.pdf). Key elements include an assessment of the scale of the market, the potential to capture a significant component of it based on outstanding scientific excellence and a commercialisation model capable of appropriating a key component of the value chain and where the technology requires the kind of sustained output identified in this submission.

- TIC's should aim to be competitive globally for contract R&D, rather than perceiving themselves as providers of services to UK industry. It is by working with the best and most demanding customers world-wide that expertise and IP is built up over time to enable spins outs and commercialisation programmes with UK companies.
- Each TIC should have 80-200 people. Experience from the Cambridge technology consultancies suggests that this is the "sweet spot" for economies of scale in R&D, though the initial start up team would obviously be smaller in most cases.
- TICs should be twinned with a single, geographically close university with existing world class competence and sizeable teams in their fields of interest (This should not of course prevent individuals and teams from any university in the UK or indeed elsewhere from using a Centre's facilities or collaborating on projects on an ad hoc basis).
- However, TIC management, administration, funding, resource allocation, remuneration and appointment processes should be entirely independent.
- CEOs should have significant experience of managing R&D in industry and an international reputation in their field.
- A **small number** of other directors or staff should also have joint positions in varying proportions in terms of the time devoted to their TIC and university roles (the Fraunhofer norm appears to be roughly two per institute)
- To ensure a development rather than research orientation, senior staff should be recruited mainly from industry. Some of those joining at graduate or post doctoral level direct from university would be expected to move into managerial positions in due course.
- Salaries should be linked to competitive industry norms rather than academic scales
- With the exception of the small number of staff at a TIC holding joint positions with the twinned university, staff should have no formal teaching roles The objective of each Centre should be to develop and commercialise; academic publications should play no formal role in performance evaluation at TIC level
- TICs should be encouraged to take a **limited number** of PhD and Masters students on secondment
- Specialised equipment should be professionally operated and managed by experienced technicians on the TICs payroll
- The funding model adopted should be based closely on the Fraunhofer Institute model:
    - a multi-element formula for the amount of core funding provided annually to reward Centres proportionally to bilateral contract income secured between 25% and 55% of total revenues

  - typical, steady state funding split target: 25% core government funding; 25% public sector contracts, EU etc; 50% bilateral private sector contracts
  - core funding guaranteed for at least 6 years on a gradually reducing rate
  - grants for major equipment investments available from Government; such equipment to be treated as a national resource

- Although the institutions we have reviewed have had very long life spans and include provision for rolling reviews within that, consideration should be given to a normal TIC life expectancy of 15 years. They should in any event be subject to major review after 10 years, with the possibility of privatisation or disbandment to follow. This would have the following benefits:
  - It would avoid TICs losing their innovative edge as the best people move on and as the new technologies on which they are based become more mainstream and more readily available from the private sector
  - It would help encourage commercialisation: the evidence from the technology consultancies and elsewhere is that loss of regular revenues can stimulate new thinking in pursuit of commercial returns and enable R&D activity to be converted into a scalable product business
  - It would release funding for the creation of new TICs

  In essence this proposal has some similarity to the way MRC research institutes are funded

- The programme for new centres should first be piloted with at most two centres, with others added after two years operational experience, if positive, at the rate of one new TIC every one to two years

Conflicts of Interest

David Connell is a one per cent shareholder in TTP Group plc and Director of TTP Capital Partners, General Partner of its venture capital fund.