

# Supporting Innovation in the 21st Century

The Benchmarking Research Institutes  
Project: Innovation and Productivity  
Grand Challenge Programme

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Research in Innovation Management

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## AIM – the UK’s research initiative on management

The Advanced Institute of Management Research (AIM) develops UK-based world-class management research. AIM seeks to identify ways to enhance the competitiveness of the UK economy and its infrastructure through research into management and organisational performance in both the private and public sectors.

AIM consists of:

- Over 300 AIM Fellows and Scholars – all leading academics in their fields...
- Working in cooperation with leading international academics and specialists as well as UK policymakers and business leaders...
- Undertaking a wide range of collaborative research projects on management...
- Disseminating ideas and shared learning through publications, reports, workshops and events...
- Fostering new ways of working more effectively with managers and policymakers...
- To enhance UK competitiveness and productivity.

## AIM’s Objectives

Our mission is to significantly increase the contribution of and future capacity for world class UK management research.

Our more specific objectives are to:

- Conduct research that will identify actions to enhance the UK’s international competitiveness
- Raise the quality and international standing of UK research on management
- Expand the size and capacity of the active UK research base on management
- Engage with practitioners and other users of research within and beyond the UK as co-producers of knowledge about management

# Contents

Contents



Tables and Figures	6
Summary	8
<b>1</b> Introduction	<b>10</b>
Methodology	12
<b>2</b> Research and Development in the UK	<b>13</b>
Collaboration in UK innovation	15
Research and Technology Institutes in the UK	16
<b>3</b> Market Structure of Research and Technology Institutes	<b>18</b>
Global presence	20
Heterogeneous customers for RTI services	20
Competition	21
<b>4</b> Services Provided by Research and Technology Institutes	<b>23</b>
Technology and innovation services	25
Winners and qualifiers for technology and innovation services	27
Assessment of technology and innovation services	27
<b>5</b> Collaboration and Open Innovation	<b>29</b>
Delivering services to customers	30
Significant collaboration	32
Latent scanning capacity through non-competitive activities	32
<b>6</b> The Innovation Performance of Research and Technology Institutes	<b>33</b>
Constraints to innovation	34
Innovation capability performance	35
<b>7</b> Future Trends	<b>37</b>
Market conditions	38
Drivers of change	36
Innovation initiatives	39
Enablers of innovation	40
<b>8</b> Conclusion	<b>41</b>
Appendix 1: Methodology	43
Appendix 2: AIRTO membership in 2009	44
References	45

# Tables and Figures

## Tables and Figures



## Tables

Table 1	Gross expenditure on R&D as a percentage of GDP for OECD countries, 1997 and 2006	14
Table 2	Services sold around the world	20
Table 3	Location of main competition	21
Table 4	List of professional business services	24
Table 5	Technology and innovation activities performed by RTIs, technology and product development	26
Table 6	Technology and innovation activities performed by RTIs, process and wider innovation	26
Table 7	Customer relationships: how RTIs contact customers for new business	30
Table 8	Most frequent non-commercial activities	32
Table 9	Capabilities that enable innovation	35
Table 10	Sample size by organisation type	43
Table 11	Sample size by employee band size	43

## Figures

Figure 1	Partners in innovation activities, cooperative active enterprises only	15
Figure 2	Trading status of AIRTO members in 2009	17
Figure 3	Industries and sectors buying RTI technology and innovation services	19
Figure 4	Share of turnover sources in 2008, by organisation type	21
Figure 5	Frequency of competition by different sectors	22
Figure 6	Important and very important business services offered by RTIs	24
Figure 7	Generic innovation process	25
Figure 8	Self-assessment of performance, all RTIs	28
Figure 9	Delivery mechanisms of technology and innovation for technology and product development	31
Figure 10	Significant and regular collaborators on innovation projects	32
Figure 11	Contribution to 2008 turnover from new services	34
Figure 12	Assessment of innovation capabilities, five highest capabilities as scored by organisation type	36
Figure 13	Market conditions 2009-2011	38
Figure 14	Drivers of change 2009-2011	39
Figure 15	Innovation activities 2009-2011	39
Figure 16	Enablers of innovation 2009-2011	40

# Summary

## Summary



- In 2009, the Association of Independent Research and Technology Organisations (AIRTO) consisted of 36 independent research and technology institutes (RTIs) which include Private Firms, Not for Profit (Private) RTIs, Government Institutions and one University Technology Centre. These organisations employ over 35,000 staff including 20,000 scientists and engineers with an aggregate annual turnover in 2007-08 of over £3 billion.
- On average, each RTI provides technology and innovation services to six manufacturing industries, three service industries and one primary resource industry. 73% of RTIs sell to enterprises in the food, beverages and tobacco products industry. The construction industry is the most important customer from the service sector.
- The UK is the predominant market for RTI services followed by other EU countries, the USA and India.
- On average, 32% of RTI turnover in 2008 was generated from services provided to the UK Government (local, national and research councils). Large manufactures account for 25% of turnover followed by small and medium size manufacturers (9%).
- All RTIs face competition from other UK organisations. Service companies are the leading competitors of private RTIs while Government Institutions and Universities encounter competition from non RTI Universities.
- RTIs are primarily front-end service providers of innovation and technology services with specialised skills in technology scanning and applied research. These organisations are also technical trouble-shooters and are competent project managers.
- 72% of those RTIs, which have fee-paying membership, offer process innovation services compared to just 25% of RTIs that do not have fee-paying members.
- On the whole, RTIs do not perform services that support wider innovation (e.g., they do not develop new marketing concepts or services that equip organisational and human resource development).
- Knowledge of specific technologies, quality of work and research capabilities are the most important customer priorities. The least important priorities include lowest price and marketing.
- Product design, proto-typing and incremental problem solving require significant customer-RTI interaction. Capability building is important to customers looking for help in new service development and process innovation projects.
- Innovation projects take on many partners. Significant collaborators include large manufacturers and Universities.
- RTIs participate in a number of non-commercial activities including business networking, attending scientific and technology conferences, contributing to academic publications and work on pre-competitive projects.
- RTIs are innovative active: between 2006 and 2008, 73% of RTIs introduced at least one new service. Not for Profit RTIs are the most innovative with 78% of 2008 turnover arising from new or improved services.
- High economic risks, high projects costs and uncertain demand for new services are some of the obstacles encountered by RTIs in their innovation activities.
- RTIs assessed their problem finding and problem solving skills and technically skilled employees to be their uppermost innovation capabilities. The lowest ranked capabilities include their knowledge management systems.

# 1

## Introduction



Innovation studies define research and technology institutes (RTIs) as intermediaries or bridging organisations in an innovation process (Bessant and Rush 1995; Hargadon and Sutton 1997; Hargadon 1998; Howells 2006; Mantel and Rosegger 1987). Howells attributes the importance of intermediate institutions in an innovation context to three factors: (1) their competence in the diffusion and transfer of technology, (2) their unique role in the management of innovation and (3) the contribution they make to systems of innovation (Howells 2006, p.716). Importantly, these knowledge brokers adapt existing technologies for new applications across industries and sectors (Hargadon 1998). Innovation service providers can also contribute and influence decisions affecting innovation in the contracting firm (Mantel and Rosegger 1987). Common throughout this discourse are the secondary and supportive roles – albeit important in some cases – RTIs perform in the innovation endeavours of other organisations.

‘Catching up’ and ‘market failure’ rationales were used to funnel public financial support towards RTIs in Europe and the USA, particularly in the post 1945 period (Abramovitz 1986). RTIs and other third party agencies were called upon to act as technology bridges between industries (Bessant and Rush 1995). It was also plausible that RTIs could provide stronger links between industry and the formal science and technology base although this was never their central role. The objective of the RTIs was to adapt, modify and render for industry applied research which had emerged from enterprises in the industry, or from other industries or, if required, from higher education. Public support meant that RTIs were not profit-seeking businesses and were loosely embedded in official science and technology policy.

The position of RTIs within the national innovation system (NIS) and sectoral innovation system frameworks is also subordinate to the core innovation activities of other enterprises (Lundvall 1992; Malerba 2002). Arnold et al recognised that RTIs contribute to innovation systems but are limited by two constraints: first, RTIs do not have the innovative capacities of their industry counterparts and, second, RTIs do not have the resources to undertake basic science research and education which are the domain of Universities (Arnold, Rush, Bessant and Hobday 1998, p.91). Instead, RTIs contribute by engaging as technology adapters that specialise in incremental innovation activities including applied research.

Direct support from the UK Government to research and technology institutes ended in the 1980s and 1990s; today’s RTIs operate in a competitive environment. The provision of technology and innovation support continues to be the focus of this sector but RTIs are now significant collaborators and engage with customers and suppliers to deliver services across different industries. Highly competent and offering specialised services throughout the world, RTIs are also high innovation performers and continuously develop new and improved service products.

This report provides an update of the market structure and activities performed by UK research and technology institutes in the early part of the 21st century. Specifically, the study presents the findings of a 2009 pilot survey. The paper discusses the following:

- 1 An overview of research and development in the UK
- 2 The industrial organisation and competitive environment of RTIs
- 3 The business services and technology and innovation services offered by RTIs
- 4 The importance of collaboration and open innovation
- 5 The innovation performance of RTIs
- 6 Possible future trends in the next two years (2009 to 2011)

The Benchmarking Research Institutes Project is part of the Innovation and Productivity Grand Challenge programme. This programme was funded in part by the ESRC/EPSRC's Advanced Institute for Management Research (AIM). AIM brings together academics, business, and policymakers to develop and deliver research, which has an immediate and significant impact on management practice.

## Methodology

Senior managers of 15 UK RTIs participated in the 2009 pilot survey. The sample was drawn from members of the Association of Independent Research and Technology Organisations (AIRTO) and a number of organisations from the wider contract research community performing similar activities as AIRTO members. Details of the methodology are in Appendix 1.

The survey sample is a fair representation of the AIRTO membership (see the section on Research and Technology Institutes in the UK below):

- The sample consists of seven private limited companies (Private Firms) (47%), five companies limited by guarantee (Not for Profit RTIs) (33%), two Government Institutions (13%) and one University (7%)
- Moreover, the breakdown of the sample by employee band size includes small organisations (40%), medium size organisations (27%) and large organisations (33%)
- 47% of the sample includes fee-paying membership organisations

The findings are presented in aggregate. The analysis is cross-tabulated by organisation type (i.e. Private Firms, Not for Profit RTIs, Government Institutions and Universities) when the findings reveal important differences.

# Research and Development in the UK



One of the original remits for providing financial support to research and technology institutions was the need to provide technical expertise within specific industries. Such services included front-end applied research and the transfer and adaptation of existing technology. Although this expertise is subordinate to the activities of the contracting organisations, it is indicative to first review the level of R&D activity from a national perspective. The amount a country spends on research and development is one measure of innovative performance.

Table 1 presents total R&D expenditures as a share of GDP for OECD countries in 1997 and 2006. In 1997 and 2006, the UK ranked 13th among OECD countries for R&D spending as a share of GDP<sup>1</sup>. From 1997 to 2006, the UK's share declined from 1.80% to 1.78% while the average for all OECD countries during this period increased from 2.10% to 2.26%.

**Table 1:** Gross expenditure on R&D as a percentage of GDP for OECD countries, 1997 and 2006

	1997 (%)	2006 (%)	Per cent change (%) 1997-2006
Australia	1.54	2.01	0.47
Austria	1.70	2.46	0.75
Belgium	1.83	1.89	0.05
Canada	1.66	1.94	0.28
Czech Republic	1.08	1.55	0.48
Denmark	1.92	2.46	0.54
Finland	2.70	3.45	0.75
France	2.19	2.10	-0.09
Germany	2.24	2.54	0.30
Greece	0.45	0.57	0.12
Hungary	0.70	1.00	0.30
Ireland	1.27	1.32	0.06
Italy	1.03	1.14	0.11
Japan	2.87	3.39	0.52
Korea	2.48	3.23	0.74
Luxembourg	-	1.67	-
Netherlands	1.99	1.73	-0.26
Norway	1.63	1.52	-0.11
Poland	0.65	0.56	-0.10
Portugal	0.59	1.00	0.42
Slovak Republic	1.07	0.49	-0.58
Spain	0.80	1.20	0.40
Sweden	3.48	3.74	0.26
Turkey	0.37	0.58	0.21
United Kingdom	1.80	1.78	-0.02
United States	2.58	2.66	0.08
<b>OECD Total</b>	<b>2.10</b>	<b>2.26</b>	<b>0.16</b>

Source: OECD 2008

<sup>1</sup> At the time of this report, Iceland, Mexico, New Zealand and Switzerland had not reported 2006 results.

The composition and share of R&D performed by different sectors in the UK has changed during this ten-year period. The share of R&D performed by the UK business sector was 62% in 2006, a decrease of 3.5% from the sector's 1997 share. The percentage of R&D performed by Government also declined during this period from 13.8% to 10% while the contribution from higher education and the Not for Profit sectors increased from 19.7% to 26.1% and 1.3% to 2.2% respectively (OECD 2008).

The falling share of R&D performed by the UK business sector corresponds to the diminishing contribution of the manufacturing sector. The manufacturing sector contributed, on average, almost 80% of total business expenditure on research and development (BERD) per annum in the late 1990s; this contribution fell to 77% in 2005. Moreover, while industry's gross value-added (GVA) grew 15% from 1997 to 2006, industry's share of total GVA fell from 24.8% to 17.5%. This was third biggest decrease among OECD countries (behind Turkey and Ireland) (OECD 2008).

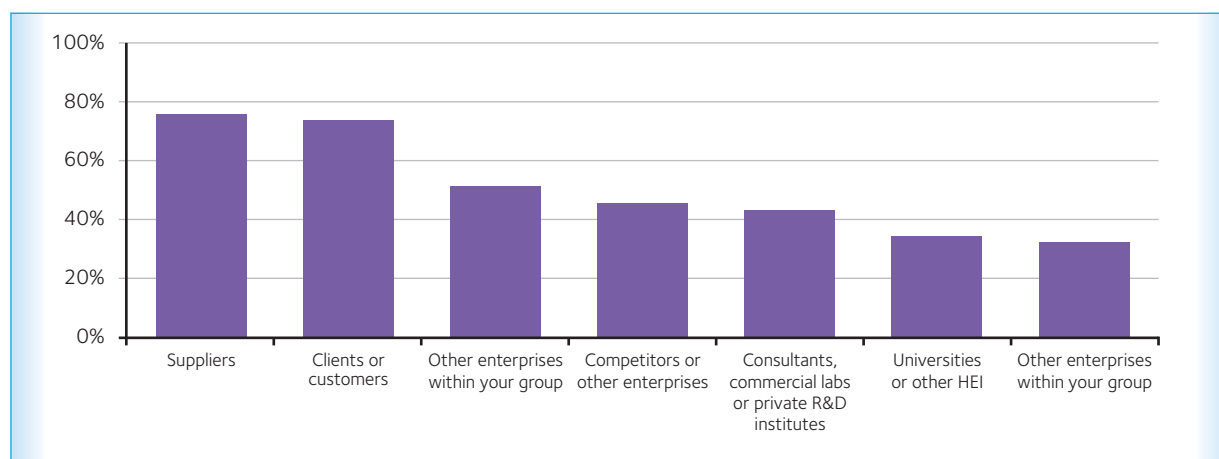
Manufacturing's decline in the share of GVA was matched by a 7.1% growth in the financial services industry in this period; however, the financial services industry share of BERD only increased from 1.5% to 3.6%. Overall, total business spending on R&D as a share of GDP fell from 1.26% to 1.09% during this period (OECD 2008). Non-manufacturing business sectors, particularly the financial service industry, did not make up for the fall in manufacturing R&D activities.

## Collaboration in UK innovation

While innovation continues to be an intra-organisational endeavour, an increasing number of initiatives occur from contractual and informal collaboration among customers and suppliers, consultancy and higher education. Open innovation is driven by the need to share risks and the recognition that technological and organisational management expertise does not reside in any one firm (Chesbrough 2003; Laursen and Salter 2006). Findings from the 4th UK Community Innovation Survey (CIS4) show that 13% of all business enterprise cooperated with external organisation on an innovation activity between 2002-2004 (DTI 2006b).

Figure 1 shows that suppliers and clients/customers are the most important external partners to those enterprises that cooperate. Taken together, specialised research organisations, including private and state-funded organisations, R&D consultants, Government laboratories and higher education are significant partners in the innovation process.

**Figure 1:** Partners in innovation activities, cooperative active enterprises only



Source: Adapted from DTI 2006

## Research and Technology Institutes in the UK

The first Research Association (RA) was launched in the UK in 1917 (Centre for the Study of Industrial Innovation 1972). The intention of this association was to raise the technical skills and production efficiency of the photographic industry. This was to be a member fee-paying organisation with a start-up grant from the UK Government. By 1925, there were 20 research associations in the UK but the results were mixed as, 'industry was slow to believe that the associations had something valuable to sell' (Centre for the Study of Industrial Innovation 1972, p.8). The height of Government support was in 1970 when 40 RAs received financial assistance from the UK Government.

Government support for science and technology institutions gradually changed from grant-in-aid towards a customer-contractor arrangement in the late 1970s and early 1980s (Rush, Hobday, Bessant, Arnold and Murray 1996). Research and technology institutes continued to receive Government funding but the arrangement became contractual. This funding arrangement led to competitive bidding for project work. The research priorities of the UK Government also changed during this period from policies that supported applied or industrial research to direct support of basic research programmes; industry was expected to pay for business-oriented research while Government would fund non-competitive and blue-sky research. Increasingly, RAs became more business-facing by offering a greater range of consultancy services. RAs faced financial uncertainty when Government financial support dried-up in the early 1990s. Several RAs continued to operate independently through management buy-outs while other RA merged or were acquired by other technology service companies. Government liberalisation policies during the 1990s also led to the privatisation of several Government laboratories. Today, RTIs are a mix former RAs, former Government labs, Private Companies, Technology Centres based at Universities and Government agencies.

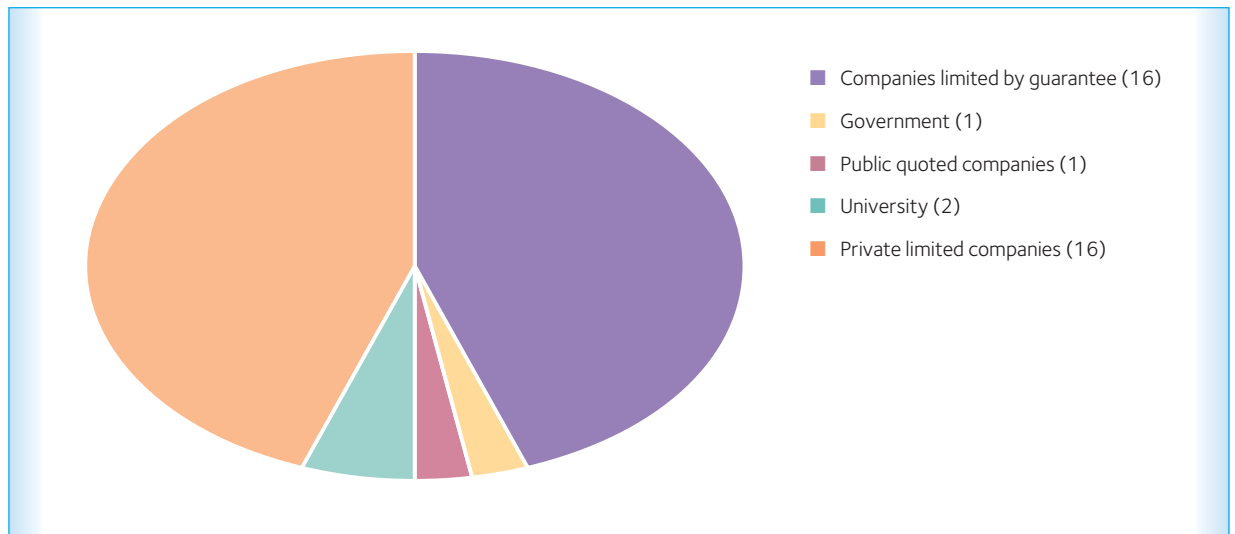
The Association of Independent Research and Technology Organisations (AIRTO) consist of 36 independent organisations<sup>2</sup> in 2009 compared to 44 members in 2001: the fall in membership has come about from mergers, acquisitions or business closings (Readman 2001). Several former members continue to operate but have opted out of the UK association. The list of the 2009 AIRTO membership is presented in Appendix 2.

Over 90% of AIRTO members are private companies (including private limited companies, one public quoted company and companies limited by guarantee). AIRTO member organisations employ over 35,000 staff including 20,000 scientists and engineers and had an aggregate annual turnover in 2007-08 of over £3 billion (derived from Company Annual Reports and AIRTO 2009)<sup>3</sup>. AIRTO members consist of 32% small organisations (from 1 to 49 employees), 27% medium size organisations (50 to 249 employees) and 41% large organisations (greater than 250 employees).

<sup>2</sup> In January 2009 two RTIs merged but are still operating as separate organisations.

<sup>3</sup> Employment and turnover figures were taken from the latest available year and do not include the two Universities or the Government agency.

**Figure 2:** Trading status of AIRTO members in 2009 (number of organisations)



Source: Adapted from Company Annual Reports and AIRTO (AIRTO 2009)

Over half (52%) of AIRTO members are listed by the UK Standard Industrial Classification of Economic Activities (2003) as 'business enterprises which perform research and experimental development on natural sciences and engineering' (ONS 2008 and Company Annual Reports). A further 18% of AIRTO members are providers of 'other business activities' while another 9% offer 'architectural and engineering activities and related technical consultancy'. The remaining members offer services in business and management consultancy, other computer related activities, technical testing and analysis and general construction & civil engineering.

Membership services are important to 42% of AIRTO members (AIRTO 2009; Company Annual Reports). Fee-paying members have access to market and technology reports, concessions on consultancy services and RTI facilities. Private Firms and Not for Profit RTIs offer membership services (47% and 53% respectively). While the importance of membership to the funding streams varies, the RTIs that offer fee-paying services value members not only as customers but also as potential collaborators on funded projects.

# 3

## Market Structure of Research and Technology Institutes



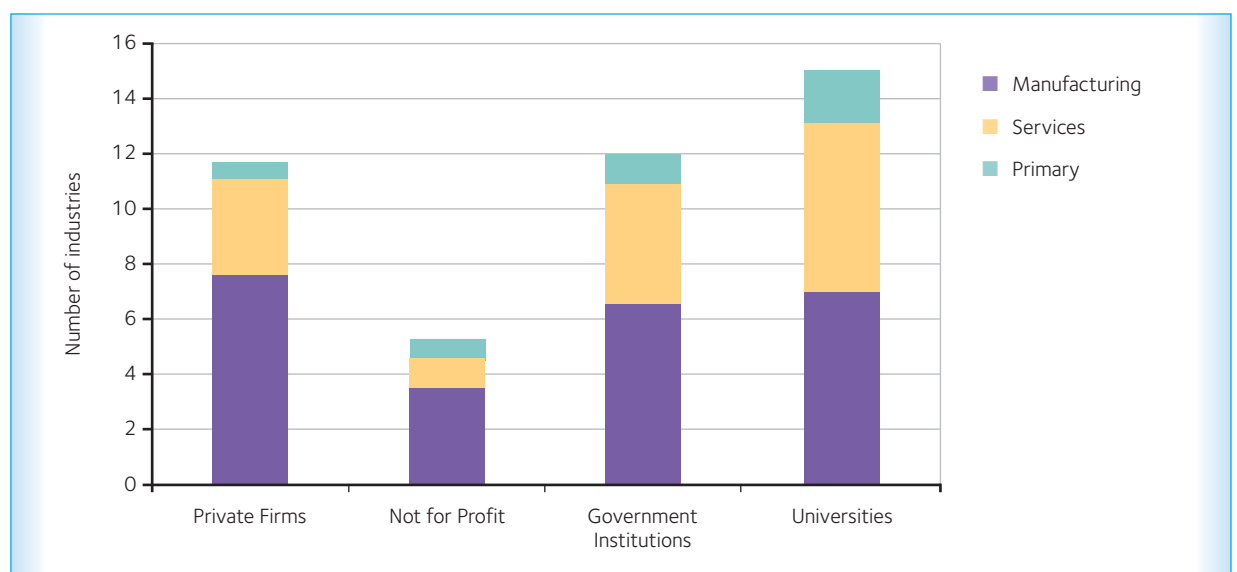
RTIs worked with businesses by supporting technological development through the transfer and adaptation of good practices in the use of technology. This support contributed to acceptance of industry standards, particularly of production process technology standards and, ultimately, to productivity increases during the post 1945 period.

Over time, and with the technologies associated with different industries overlapping, the industry focus was extended to a technology-orientation. Some RTIs became technology bridges between industries and sectors rather than industry specialists (Bessant and Rush 1995).

Moreover, meeting the needs of customers became more important and this customer focus lessened any industry lock-in. This technology-orientation continues today as UK RTIs indicated they sell technology and innovation services to an array of industries.

RTIs indicated that, on average, they sell technology and innovation services to six manufacturing industries, three service industries and one primary resource industry. Universities sell services to the greatest number of industries (15), which reflect the diverse nature of this specific technology centre. Both Government Institutions and Private Firms sell services to 12 industries while Not for Profit RTIs sell to customers in five industries. This suggests that the Not for Profit RTIs may have a narrower technology or industrial focus than other RTIs.

**Figure 3:** Industries and sectors buying RTI technology and innovation services



N=15

All four organisations focus on the manufacturing sector to a greater extent than the service sector. The food products industry (including beverages and tobacco) purchases services from 73% of RTIs. 60% of RTIs sell to customers from four industries: the chemical products and man-made fibres industry, rubber and plastic products, basic metals and fabricated metal products and electrical and optical equipment. Over 53% of RTIs sell to the construction industry (the most important service industry purchasing RTI services).

## Global presence

The UK is the predominant market place for RTIs, followed by the EU (other EU countries), the USA and India. RTIs sell their service, on average, to buyers in four markets including the UK. 27% of RTIs only sell to customers in the UK while one RTI (4%) has a presence in eight markets. Organisation size is a characteristic of market presence with small companies, on average, selling to three markets and medium and large organisations selling to four markets each.

**Table 2:** Services sold around the world (per cent of respondents)

	Markets (%)
UK	100
EU	60
USA	53.3
India	46.7
China	33.3
Other international	26.7
Japan	20
Other Asia excluding China and India	6.7

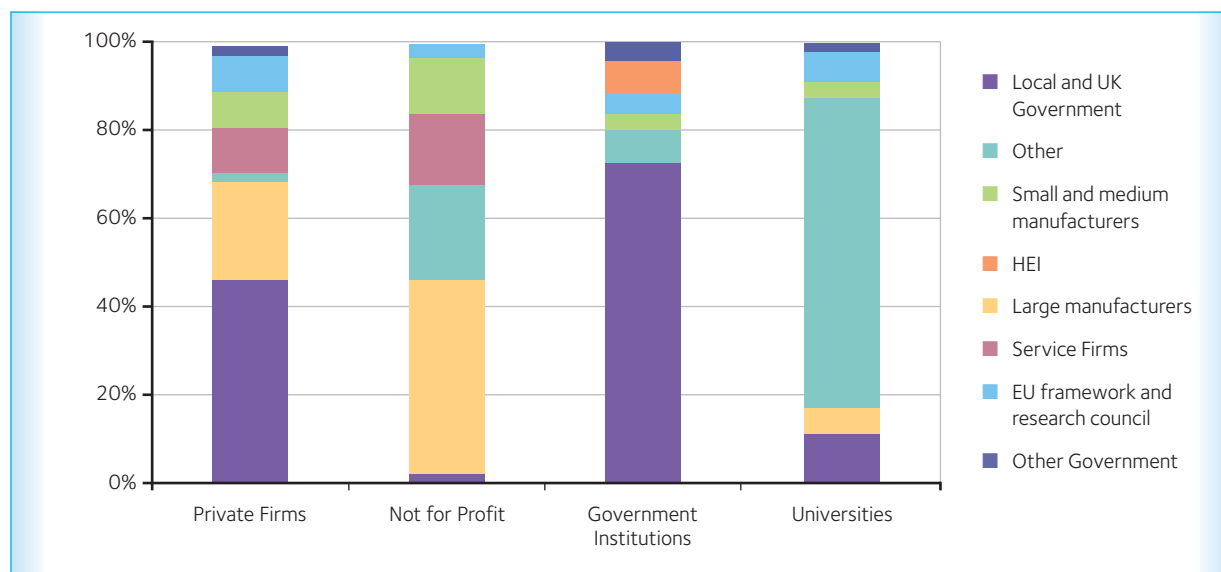
N=15

## Heterogeneous customers for RTI services

RTIs also sell services to a host of different organisations. On average, 32% of total RTI turnover in 2008 arose from the sale of services to the UK Government (local, national and research councils). Large manufactures account for 25% of turnover followed by small and medium size manufacturers (9%). The share of turnover contributed by different customers varies if segmented by the type of RTI. Specific differences include:

- The UK Government (local and national) is the most important customer for Private Firms and Government Institutions (43% and 73% of turnover respectively). Government sales account for only 1% of the turnover of Not for Profit RTIs
- Large manufacturers account for 44% and 22%, respectively, of the turnover of Private Firms and Not for Profit RTIs
- The share of turnover attributed to small and medium size manufactures is 13% for Not for Profit RTIs and 9% for Private Firms. SMEs account for 3% of turnover for both Government Institutions and Universities
- Service Firms account for 18% and 12%, respectively, of the turnover of Not for Profit RTIs and Private Firms. Not for Profit RTIs work predominately with small and medium size service companies while Private Firms work with large service companies
- Neither Government Institutions nor Universities work with the service sector on a commercial basis.

**Figure 4:** Share of turnover sources in 2008, by organisation type



N=15

## Competition

All RTI face competition from UK based organisations. Furthermore, 47% and 13% of RTIs, respectively, stated that they encounter competition from the USA and other EU countries.

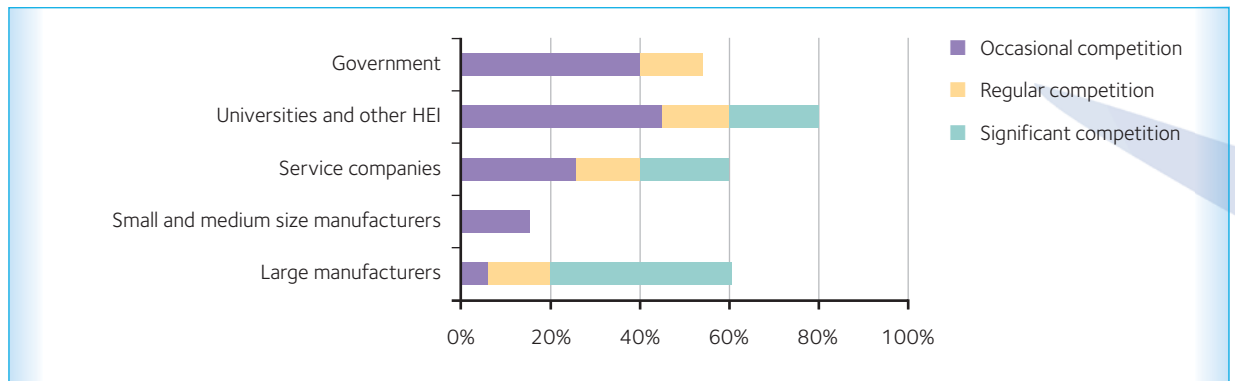
**Table 3:** Location of main competition

	Per cent of respondents (%)
UK	100
USA	47
Other EU	13
Japan	7

N=15

On average, RTIs face regular and significant competition from HEI and service companies. Large manufacturers are significant rivals unlike SMEs, which are not.

**Figure 5:** Frequency of competition by different sectors (per cent of respondents)



N=15

Breaking down the competition analysis, different types of RTIs face the following rivalry:

- Service companies are the most important competitors of Private Firms
- Public sector RTIs compete against other public sector organisations: Universities and other HEI are the main competitors encountered by Government Institutions and University RTIs
- Large manufacturers are the main competitors of Not for Profit RTIs although, on average, Not for Profit RTIs did not rank any particular sector as a regular or significant competitor

# Services Provided by Research and Technology Institutes

# 4



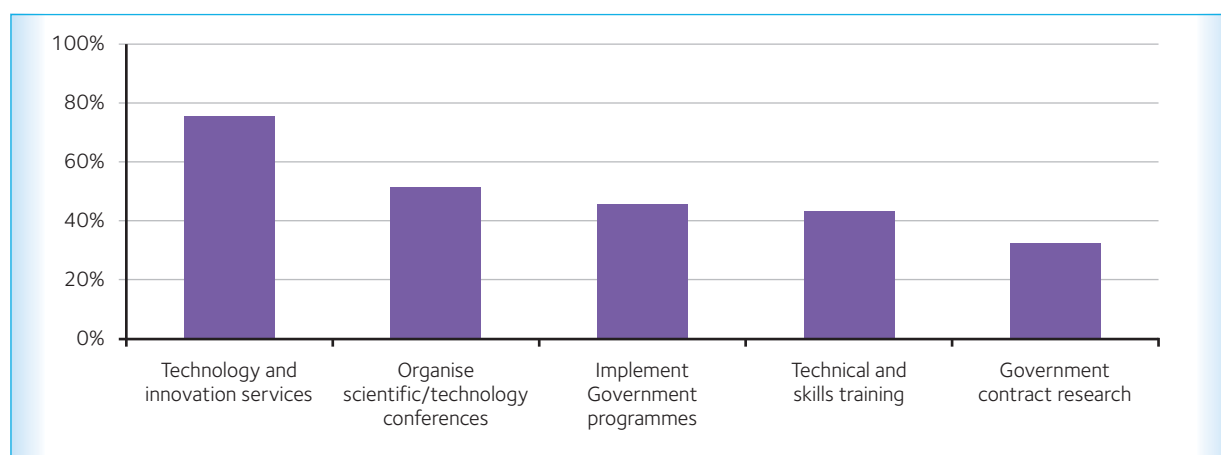
This study investigated the different business services that RTIs offered in 2008. The services were identified using broad categories associated with business and technology consultancy provision (see Table 4). Managers of RTIs were asked if these services contributed to 2008 turnover by using the following scale: very important (strategic focus of the business), important, somewhat important or not important (but offered). Respondents could also indicate if a service is not offered.

**Table 4:** List of professional business services

Technology and innovation services	Testing of standards or certification (e.g. ISO certification)
Patent search and registration	Government contract research (e.g. research councils)
Financial and administration management consultancy	Design of Government programmes or projects
Technical skills training	Implementation of Government programmes or projects
Risk management	Government project and programme evaluations
Business strategy formulation	Establishing industry and national standards
Market and brand research	Organise scientific or technology conferences
Operational services (e.g. maintenance, software support)	Organise business or management conferences
Production services (e.g. short batch-runs)	

RTIs offer, on average, eight services. Medium and large organisations offer 10 services each while small organisation offer, on average, six services. RTIs maintain that technology and innovation services are the most important business service with 87% indicating that this service is either important or very important to the turnover base. Other service deliveries are not as predominant: for example, the second most important service product (organising scientific and technology conferences) was offered by 53% of respondents. The next three services (implementing Government programmes, technical skills training and Government contract research) are important to 47% of respondents. Financial and administration management consultancy, operational services and production services are not offered or not important to over 80% of RTIs.

**Figure 6:** Important and very important business services offered by RTIs



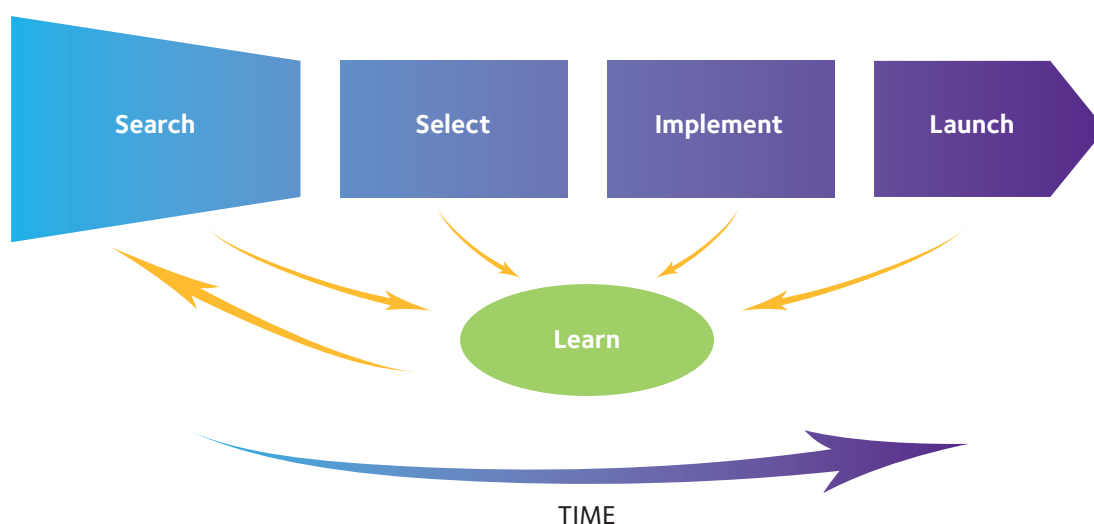
N=15

## Technology and innovation services

The different technology and innovation services used in this study follow a (linear) innovation process, particularly a technology-push process, and include scanning, selection, research, development, implementation and product launch activities (Kline and Rosenberg 1986; OECD 2005). This generic process is used for convenience and should not be misconstrued as an endorsement of a linear innovation framework. Innovative endeavours have different stages and reiteration and consist of intersections with different functions within an organisation and, increasingly, with collaborators.

In addition to creating a simplistic and unrealistic model, the logic of a linear innovation process, and the associated functions and activities, does not necessarily correspond to the commercial services offered by technology and innovation service providers. Many technology and innovation activities are often bundled together in a service offering. Decoupling each function and associating it to the contribution to turnover (for example) would be impractical. Therefore, respondents were asked only if they performed the service. The service activities identified in this study follow the innovation activities proposed by the OECD's Oslo Manual (OECD 2005).

**Figure 7:** Generic innovation process



Adapted from: Tidd, Bessant and Pavitt 2005

The different technology and innovation services offered by the RTIs are reported in Table 5 and Table 6. RTI are front-end service providers of innovation and technology services. These organisations have unique competences in technology scanning and applied research. The most prevalent services that support technology and product innovation include:

- Acquisition of scientific/technical information
- Applied research
- Solving technical problems
- Feasibility studies

Only a small number of organisations (6.7%) performed activities directed at the commercialisation stages of the innovation process (e.g. launching products into the market place).

**Table 5:** Technology and innovation activities performed by RTIs, technology and product development

	Per cent of organisations (%)
Acquisition of scientific/technical information	93.3
Feasibility studies	80.0
Basic research	73.3
Applied research	93.3
Product development	73.3
Product design	53.3
Design of prototypes	53.3
Solve scientific; engineering or technical problem	93.3
Managing innovation projects	86.7
Market and customer research for new products	33.3
Launch products/services into the market place	6.7

N=15

The biggest difference arises in the provision of process innovation services with 72% of fee-paying member RTIs offering services compared to just 25% of non fee-paying RTIs. This indicates that fee pay member organisations look to RTIs for support to improve operational practices: for example, lean manufacturing consultancy services. On the whole, RTIs do not perform services that support wider innovation such as developing new marketing concepts and, to a lesser extent, organisational development and change services.

**Table 6:** Technology and innovation activities performed by RTIs, process and wider innovation

	Per cent of organisations (%)
Developing new services for customers	33.3
Process innovation	46.7
Organisational change consultancy	13.3
Developing new marketing/advertising concepts	0

N=15

## Winners and qualifiers for technology and innovation services

What are customers looking for when procuring technology services? RTIs were to asked to rank, in terms of importance, the criteria customers use when evaluating technology and innovation service providers. Adapting the order winner/order qualifier model suggested by Terry Hill, respondents categorised each criterion as either 5 – critical (will win an order); 4 – very important; 3 – important (qualifying threshold); 2 – less important or 1 – not important (Berry, Hill and Klompmaker 1995).

The seven most important criteria used by customers for evaluating technology and innovation service providers are (ordered by importance):

- 1 Knowledge of specific technologies
  - 2 Quality of work
  - 3 Research capabilities
  - 4 On-time completion
  - 5 Physical facilities
  - 6 Customer relations
  - 7 Brand name and reputation
- 

All four RTI types (i.e. Private Firms, Not for Profit RTIs, Government Institutions and Universities) acknowledge that *knowledge of specific technologies* is the most important customer criterion with *quality of project work* and *research capabilities* scoring above very important. The least important factors include offering customers the lowest price and marketing services: RTIs scored both factors below the qualifying order threshold. According to the informed views of RTI managers, customers weigh quality and technological capabilities over cost.

## Assessment of technology and innovation services

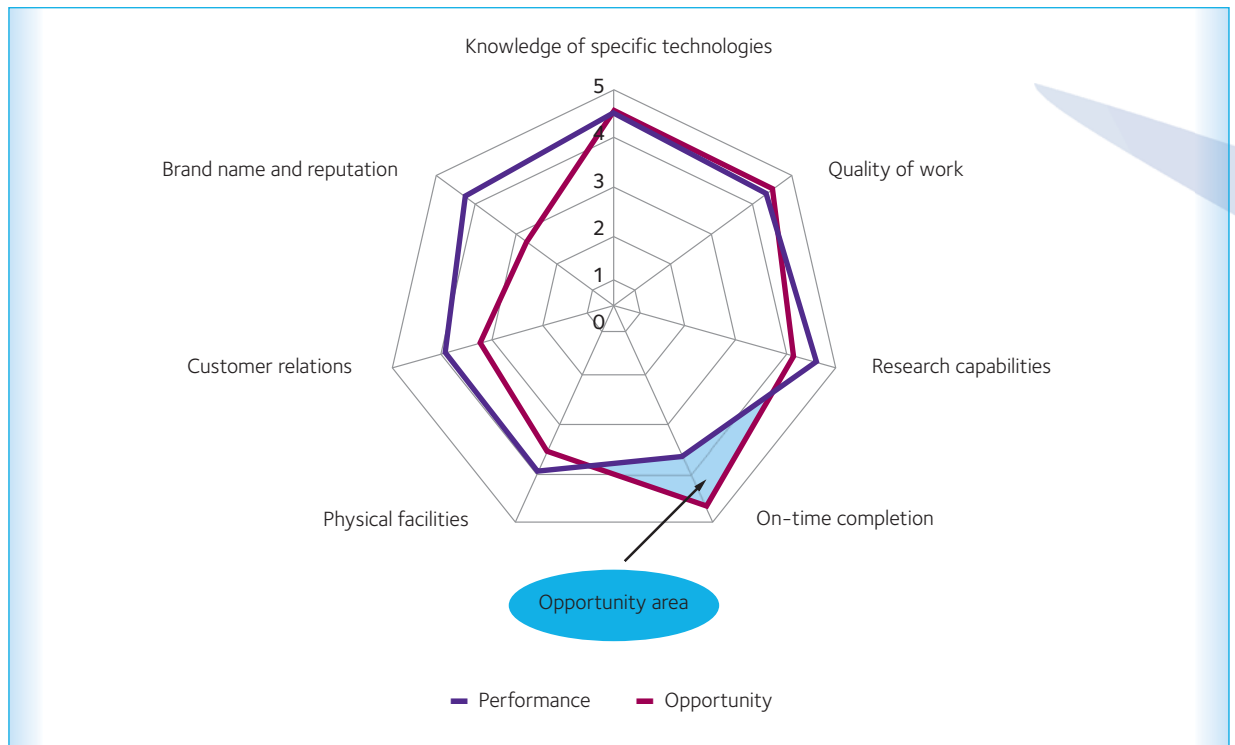
Self-assessment techniques are a useful method to evaluate performances such as organisational capabilities and skill levels but care is required to ensure that participants have sufficient knowledge of the organisation and that they understands the nature and scope of the inquiry<sup>4</sup> (Voss, Chiesa and Coughlan 1994). Senior managers were asked to assess their organisation's performance of the selected customer criteria (above) using the following scale: 5 – international standard; 4 – national standard; 3 – satisfactory but could be improved; 2 – poor and 1 – does not exist.

Organisation can use importance and assessment ranking data to identify performance gaps. This gap – called an *Opportunity Index* – follows a simple algorithm that gives more weight to the customer importance score than to the assessment score (see Ulwick 2002). This procedure emphasises the customer criteria which is more important<sup>5</sup>. Figure 8 illustrates a comparison of the self-assessed performance to the opportunity score for the seven most important customer criteria.

<sup>4</sup> Senior managers and company directors participated in this study.

<sup>5</sup> The opportunity index formula is:  $O = I + (I - S)$ , where I equals the importance score given to each criterion; S equals the assessment score given to each criterion and O equals the opportunity index.

**Figure 8:** Self-assessment of performance, all RTIs



N=15

RTIs perform extremely well in the assessment of organisational performance. The one area that could be improved – where the opportunity score is higher than the performance score – is the on-time completion of project activities. A small opportunity also could be explored in regards to quality of work issues but the gap is extremely narrow. RTIs fair even better in the less important customer criteria with performance outdistancing any opportunity score. The true test will occur if direct customer assessments are introduced. However, the results of this technique are encouraging and suggest that RTIs are world leaders in providing value to customers in technology and innovation service delivery.

# Collaboration and Open Innovation



Collaboration with other businesses is a strategic activity for many organisation in their day-to-day operations and in their innovation practices. For example, as manufacturers shed production to local or off-shore suppliers, managing the supply base requires closer integration. Critical parts and components can no longer be purchased through arms-length spot markets; closer co-ordinated production scheduling between suppliers and lead companies can often lead to common inter-organisational programmes, e.g. continuous improvement in supply chains (Bessant, Kaplinsky and Lamming 2003).

While learning takes place in supply chain, organisations are also establishing formal collaborations to develop new technologies and products. Strategic collaboration is essential as technologies have become more complex and the capabilities required to develop the next generation of products means that no one firm can go it alone (Iansiti 1995; Katz and Allen 1985). Moreover, firms also compete through innovation performance. Inter-organisational collaboration can accelerate the development process, thereby providing advantages to firms for faster product releases and the ability to control when new products are launched (Di Benedetto 1999; Rothwell 1994). Finally, open innovation strategies allow firms to distribute risks and development costs among partners (Chesbrough 2006). Open innovation has emerged as an important competitive strategy in the innovation process.

By their very nature, RTIs provide services to organisations engaged in innovative activities. Working with clients is a characteristic of these services; what vary are the mechanisms used to deliver the different services. RTIs also call upon a unique set of contractors and suppliers in the development and delivery of these services. While the relationships with customer and supplier are set in a business context, RTIs have also established links with Universities and other institutions (from the public and private sectors) that are more open-ended and not tied to a commercial outcome. Non-commercial networks and activities can potentially lead to new business and innovative undertakings. The next part explores the importance RTIs place on customer and supplier collaboration and on non-commercial activities.

## Delivering services to customers

Customer relationships are paramount to organisations offering strategic services. This is evident by the value placed on returning business and customer referrals. All RTIs indicated that new project business is obtained from customers known from previous projects while 73% noted that new business arises from referrals. Nonetheless, pursuing leads, either through their own initiatives or by participating in business networks, is important for new business opportunities.

**Table 7:** Customer relationships: how RTIs contact customers for new business

	Per cent of respondents (%)
Known from previous projects	100
Company's initiatives	93
Network meetings	87
Recommendations from other customers	73
Invitations for tender	60

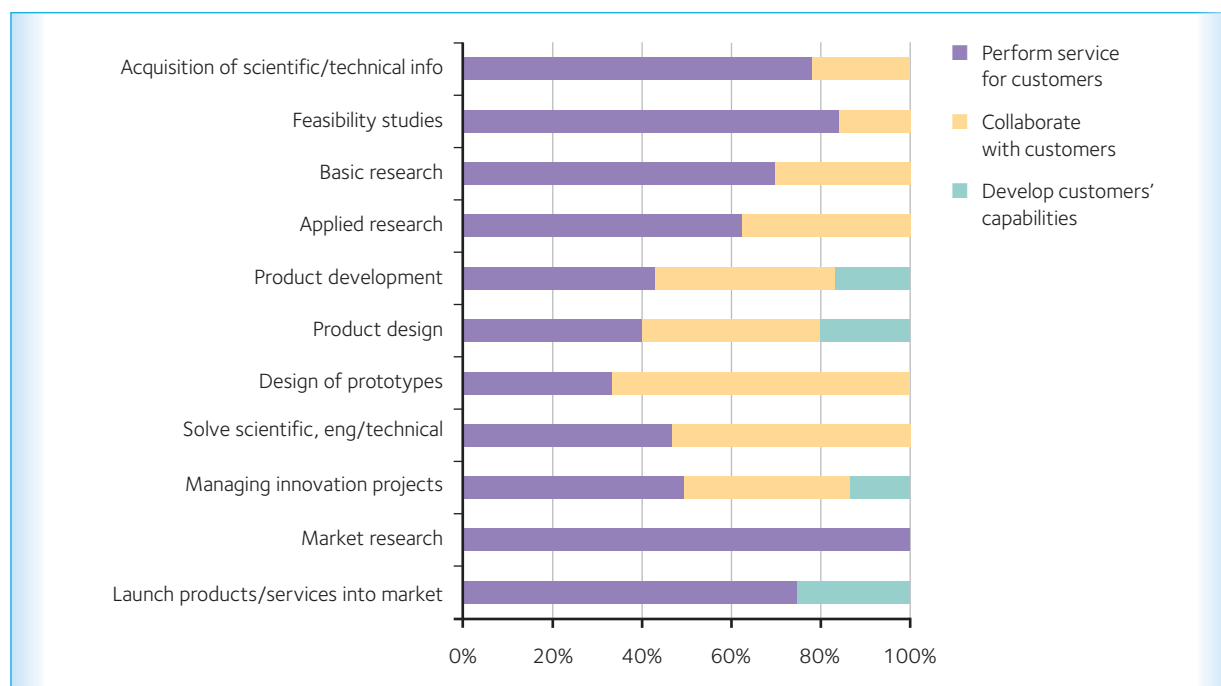
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How RTIs work with their customers is another unique characteristic of technology and innovation service provision. Consultancy services can be delivered in three forms:

- 1 The consultant does the work on behalf of the client. The RTI will often be placed in a sub-contracting role. For example, the application of technical services will be performed by the RTI with very little interaction with the client other than the initial negotiated phase to set the terms of reference.
- 2 The consultant and client work together. Both the client and service provider contribute technical expertise to the project.
- 3 In some cases, the consultant will be responsible to develop and embed specific capabilities in the contracting organisation. The consultant may provide technical expertise in addition to training, coaching and mentoring staff.

Performing the activity on behalf of customers and collaborating with customers are the most common modes of delivering technology and innovation services. Figure 9 shows that for technology and product development services, the middle range of activities in the innovation process (product design, proto-typing and incremental problem solving) require greater client collaboration than the earlier stages (scanning and feasibility studies). RTIs develop customer capabilities in product development activities (20% of RTIs upgrade these capabilities) and design (17% of RTIs), and, to a lesser extent, project management (14% of RTIs).

**Figure 9:** Delivery mechanisms of technology and innovation for technology and product development (per cent of respondents)



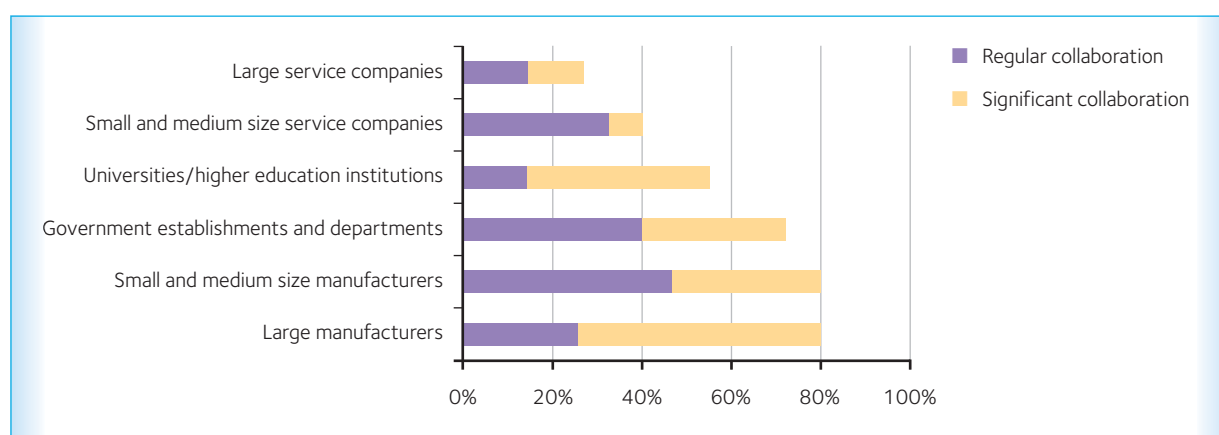
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In contrast, customers require greater capability building in new service development and process innovation. Of those RTIs engaged in new service development and process innovation, 42% and 29%, respectively, develop the capabilities of customers.

## Significant collaboration

RTIs provide technology and innovation services to contracting organisations as sole agents or part of a larger group. In many situations, RTIs are the lead contractor and call upon other organisations to provide technical and organisational skills to support the innovative endeavour. Figure 10 shows that manufacturing companies are the most important collaborator: 80% of RTIs have regular and significant collaboration with large manufacturers and small and medium size manufacturers. Figure 10 also reveals that 40% of RTIs considered higher education institutions to be the second most important collaborator after large manufacturing companies.

**Figure 10:** Significant and regular collaborators on innovation projects (per cent of respondents)



N=15

## Latent scanning capacity through non-competitive activities

Firms that are active in R&D have capabilities that allow them to learn from existing knowledge bases and capabilities to produce new knowledge (Cohen and Levinthal 1989). Absorptive capacity is a dual process that entails external scanning capabilities of new knowledge such as breakthrough technologies and the capabilities to internally integrate external knowledge (Arbussa and Coenders 2007). Moreover, scanning activities are occasionally open-ended with no pre-defined outcomes or objectives. For example, meetings with potential partners at business network events or scientific collaborators are non-commercial activities that may pay-off in the future. The benefits of these non-commercial activities are latent but often enable absorptive capacity.

RTI participate in several non-commercial activities, which have potential technology and innovation scanning outcomes. The most popular non-commercial activities are listed in Table 8 and include business networking, attending scientific and technology conferences, contributing to academic publications and work on pre-competitive projects.

**Table 8:** Most frequent non-commercial activities

	Per cent of respondents (%)
Known from previous projects	100
Company's initiatives	93
Network meetings	87
Recommendations from other customers	73
Invitations for tender	60

N=15

# The Innovation Performance of Research and Technology Institutes

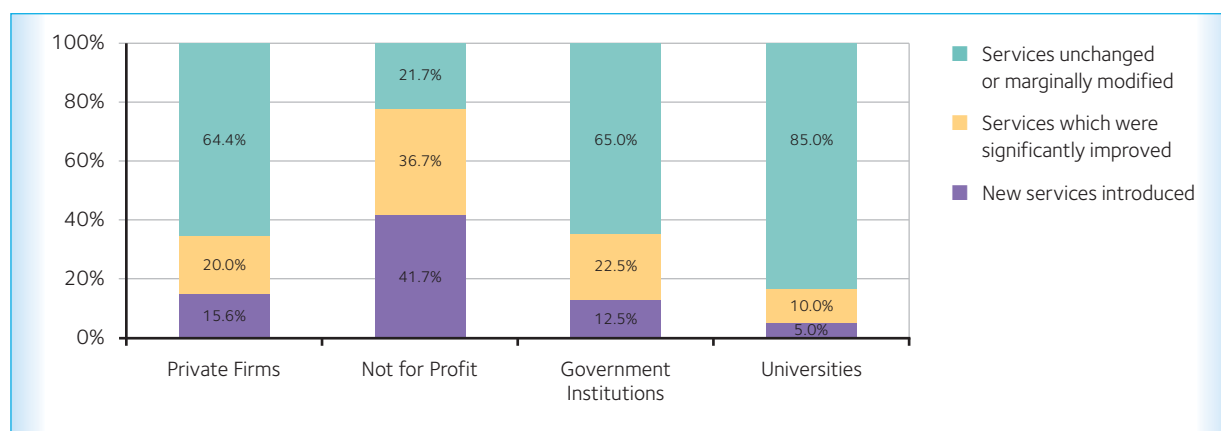


We tend to view research and technology institutes as intermediaries that support the innovation activities of others. In fact, the research and development service industry is innovative active: over 48% of R&D service providers in the natural science and engineering introduced a new product or service between 2002 and 2004 while, on average, only 25% of all UK firms introduced a new product or service during this period (DTI 2006c; DTI 2006b).

As a sub-set of the wider research and development service sector, UK RTIs are extremely innovation active. New services were introduced by 73% of RTIs and existing services were significantly improved by 80% of RTIs between 2006 and 2008. Service innovation also has a significant impact on turnover. New services contributed, on average, 20% to turnover while significantly improved services contributed 23%. The contribution of service innovation to 2008 turnover, grouped by organisation type, is presented in Figure 11. This Figure reveals that:

- Not for Profit RTIs are the most innovative with 78% of 2008 turnover coming from new or improved services
- Service innovation accounted for 36% of turnover in 2008 for both Private Firms and Government Institutions
- The Technology Centre at the University RTI realised 15% of their turnover from service innovation

**Figure 11:** Contribution to 2008 turnover from new services



N=15

## Constraints to innovation

RTIs were asked if they encountered any obstacles during the development or launch of their new service initiatives from 2006 to 2008 (including developments which were abandoned). The list of constraints is similar to that suggested by the UK 4th Community Innovation Survey with additional factors introduced to account for the importance placed on collaboration by RTIs.

RTIs encounter the following economic obstacles in their innovation activities including (ranked by importance): excessive perceived economic risks, direct costs of the project were too high and uncertain demand for new services. Other obstacles encountered by RTIs include a low assessment of internal organisational capabilities and the capabilities of potential collaborators. Furthermore, RTIs noted that the lack of quality collaborators hinders their innovation activities.

## Innovation capability performance

RTIs were asked to evaluate their organisation's capabilities to develop and launch new services. Innovation capabilities represent a number of behaviour routines and enablers that, when bundled together, perform a stage or function in a generic innovation process (see Figure 7). The capabilities also include meta capabilities which can affect learning to improve their application (Caffyn and Grantham 2003; Collis 1994). The list of the 13 capabilities is presented in Table 9<sup>6</sup>.

**Table 9:** Capabilities that enable innovation

Scanning trends (e.g. benchmarking, forecasting)
Strategies that support innovation
Technically skilled employees
Creativity practices
Problem finding and problem solving skills
Management and leadership
Use of technology (e.g. CAD)
Implementation (e.g. project management)
Reviews, monitoring, evaluations
Financial management
Working with customers
Working with suppliers or sub-contractors
Knowledge management systems

Adapted from: Tidd, Bessant and Pavitt 2005

Capabilities were assessed using the following preferences: international standard, national standard, satisfactory (but could be improved) and poor. RTI managers could also indicate if the capability does not exist in the organisation.

The highest ranked capabilities (in order of their position) for all RTIs are<sup>7</sup>:

- 1 Problem finding and problem solving skills
- 2 Technically skilled employees
- 3 Working with customers
- 4 Strategies that support innovation
- 5 Management and leadership

<sup>6</sup> A comprehensive list of innovation capabilities would be too lengthy for a survey instrument.

<sup>7</sup> The preceding number indicates the rank position.

Mid-ranking capabilities are:

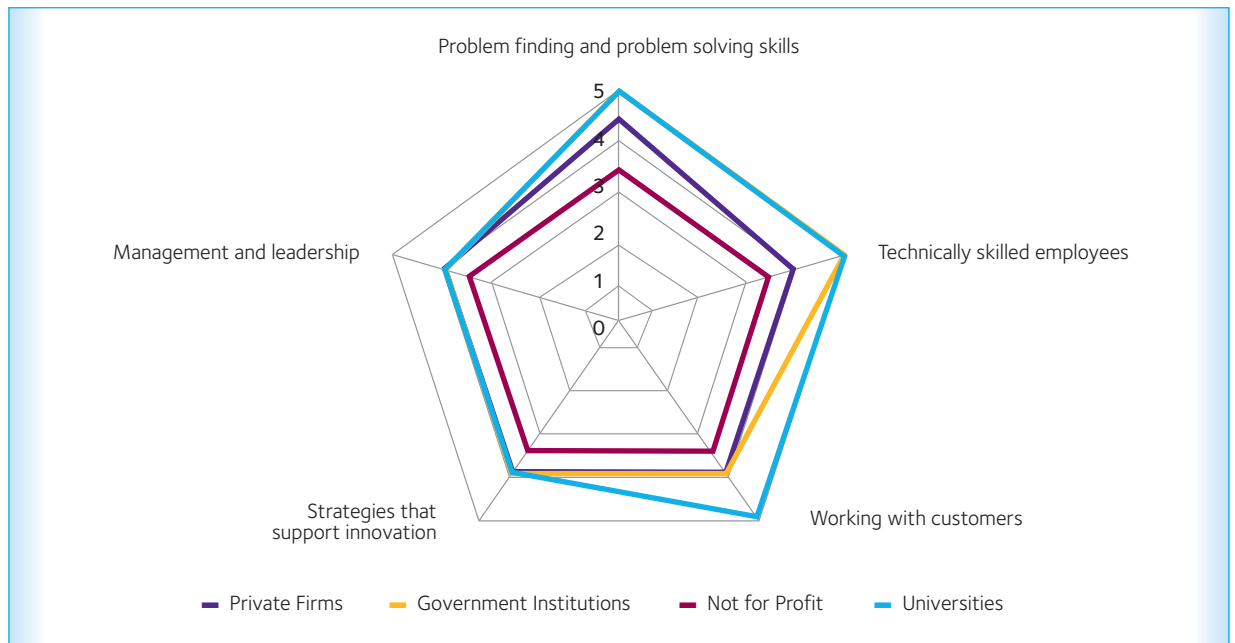
- 6 Creativity practices
- 7 Financial management
- 8 Use of technology (e.g. CAD)
- 9 Implementation skills (e.g. project management)
- 10 Working with suppliers or sub-contractors

The lowest ranked capabilities scored between satisfactory and national standard and include:

- 11 Knowledge management systems
- 12 Scanning trends (e.g. benchmarking, forecasting)
- 13 Reviews, monitoring, evaluations

A different picture emerges if this assessment is cross-tabulated by organisation type. First, Universities and Government Institutions, on average, assessed the greatest number of innovation capabilities at an international or national standard. Second, the Not for Profit RTIs, on average, consistently assessed their capabilities lower than other RTIs. Finally, Private Firms and Not for Profit RTIs saw the least variation among their innovation capability scores. This low disparity among assessed capabilities could indicate an innovation process which is more fully developed in the private sector organisations than in the public sector organisations (i.e. Government Institutions and Universities).

**Figure 12:** Assessment of innovation capabilities, five highest capabilities as scored by organisation type



N=15

# Future Trends

# 7

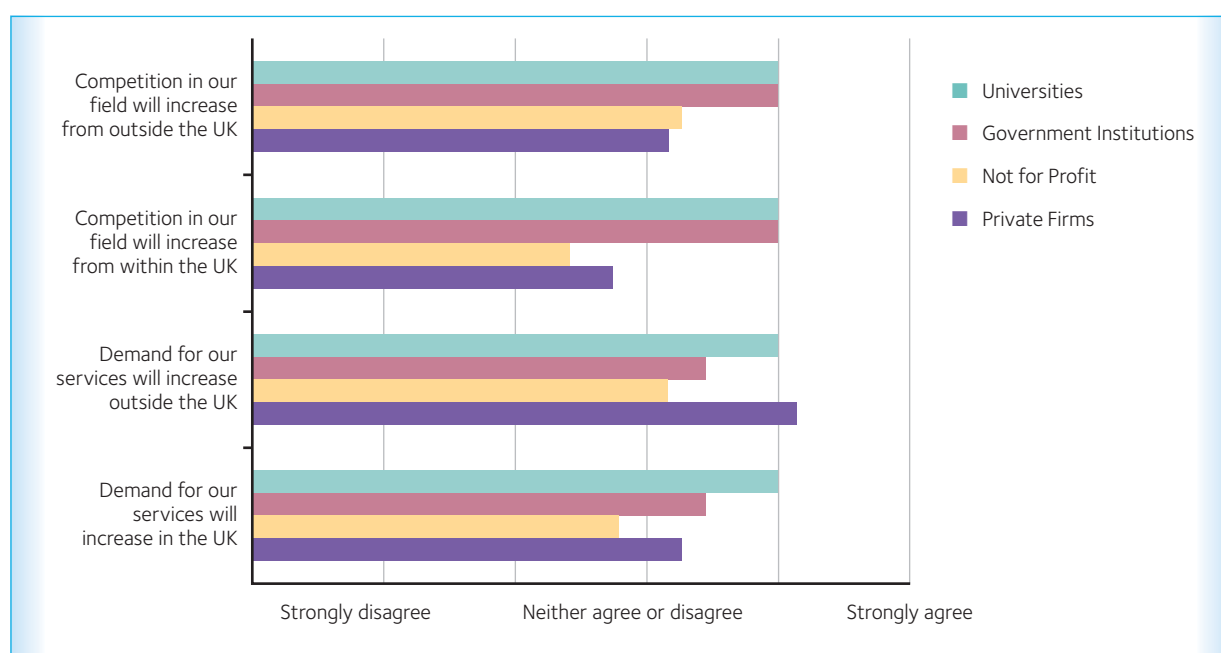


RTI managers were asked to reflect on a number of future trends which may occur during the next two years (2009 to 2011). The inquiry focused on perspectives of the market place, drivers of change, innovation initiatives and innovation enablers.

## Market conditions

Competition is expected to increase in the UK and abroad for Government Institutions and Universities. For service providers in the private sector (i.e. Private Firms and Not for Profit RTIs), competition is expected to increase more in non-UK markets than in the UK. Overall, public sector service providers foresee competition increasing to a greater extent than private sector service providers.

**Figure 13:** Market conditions 2009-2011



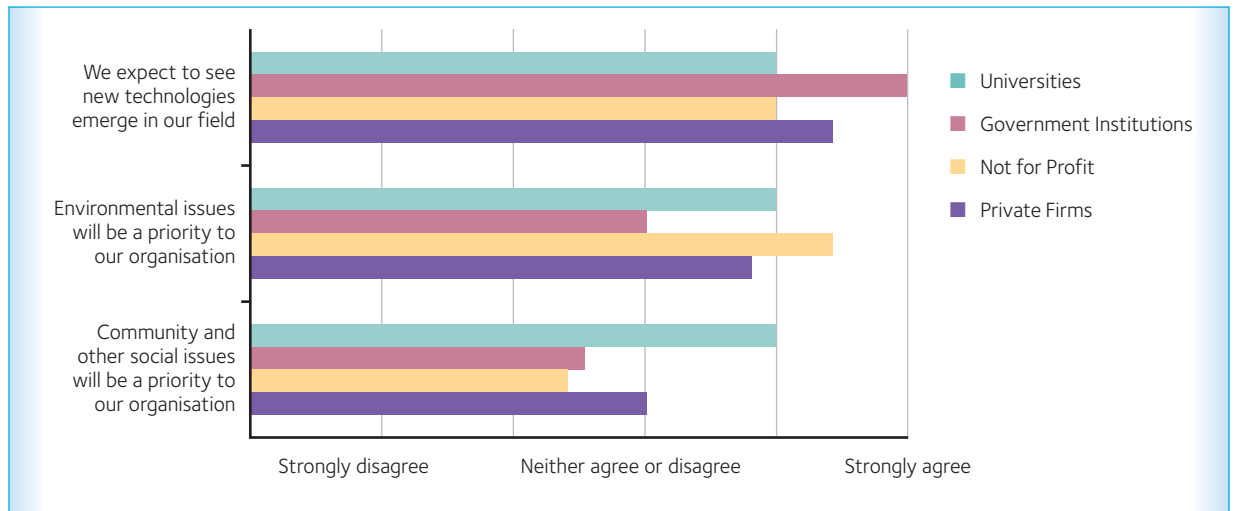
N=15

Demand for services in the UK and abroad is expected to increase for Universities. Private Firms expect demand to increase outside the UK but only moderately in the UK. Not for Profit RTIs have a negative view of UK demand conditions and expect a moderate slow-down. Finally, Government Institutions are cautiously positive about demand growth.

## Drivers of change

Only Universities expect community and social issues to be priorities in the next two years. Overall, environmental issues are slightly more important but only Universities and Not for Profit RTIs agree that the environment will become a priority. All RTIs expect new technologies to emerge in their field.

**Figure 14:** Drivers of change 2009-2011

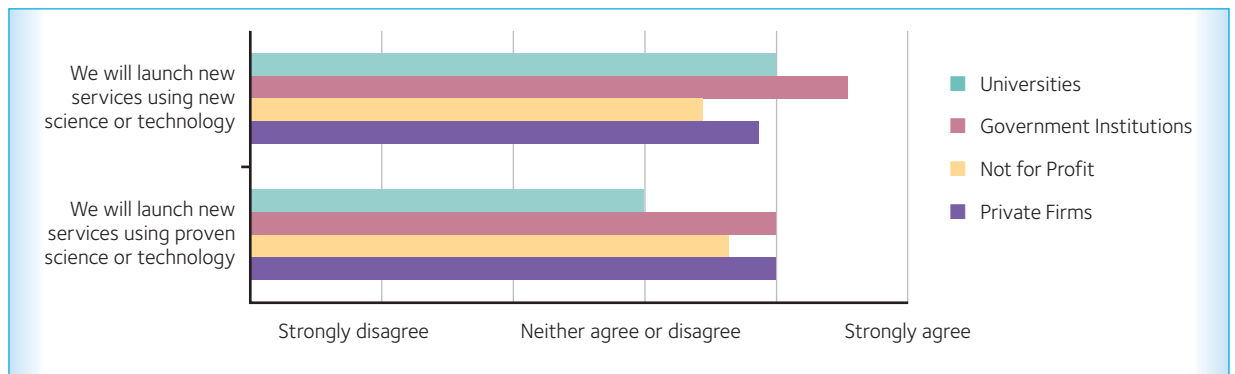


N=15

## Innovation initiatives

Government Institutions and Universities indicated that they expect to introduce new services, which incorporate new science or technologies, rather than services that use proven sciences and technologies. Alternatively, Private Sector Firms (Private Firms and Not for Profit RTIs) expect to launch new services, which rely on existing technologies, rather than services which incorporate new science or technologies.

**Figure 15:** Innovation activities 2009-2011

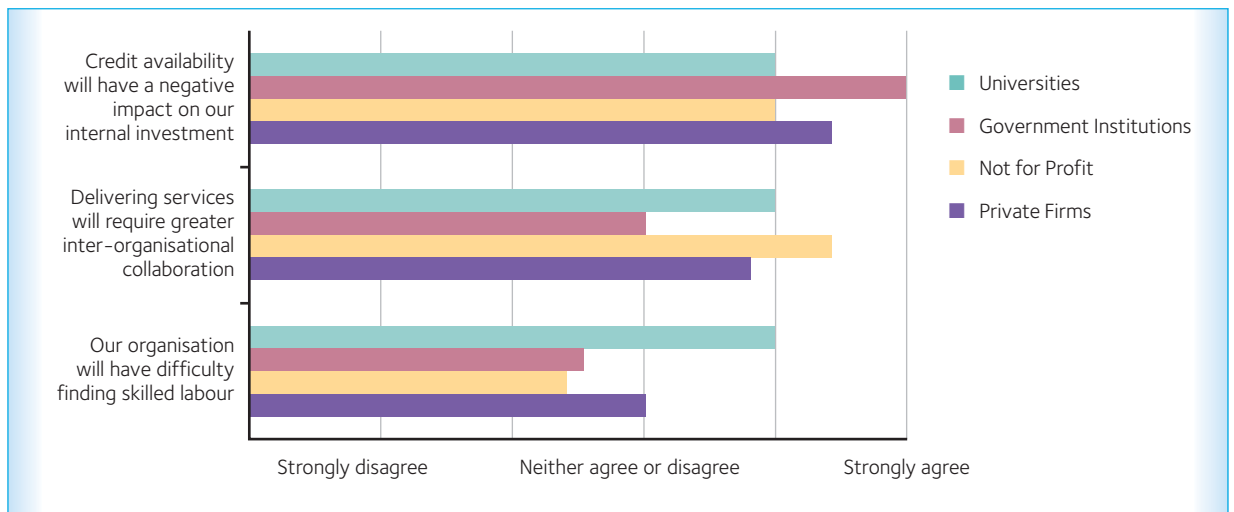


N=15

## Enablers of innovation

Finally, managers of RTIs were asked if they expect their ability to develop innovations to change in the next two years. The most noticeable change is the expectation that inter-organisational collaboration will increase. Collaboration includes working closer with customers, suppliers and other performing organisations. The (lack of) availability of skilled labour is expected to cause difficulties to some Government Institutions and, to a lesser extent, Private Firms. Only Universities see the availability of credit to have a very negative impact on investment activities: in fact, Government Institutions strongly disagreed with the negative statement referring to credit availability.

**Figure 16:** Enablers of innovation 2009-2011



N=15

# Conclusion 8



This study is relevant to the current debate in the UK on productivity, innovation and services (DTI 2003; DTI 2006a). RTIs are pertinent to technology and product innovation and provide expertise in up-front technology scoping and scanning, applied research and technical and engineering problem solving. By supporting the innovation endeavours of other organisations, RTIs have established long standing relations with firms in the manufacturing and service sectors. They have also been instrumental in the implementation of Government programmes. These roles may become even more pivotal as open innovation increasingly becomes a strategic activity (Chesbrough 2003).

UK research and technology institutions have also proven to be resilient: not only have they weathered financial uncertainty, many RTIs have become global leaders in their field. Several common traits include:

- 1** RTIs compete in several national and overseas markets and several organisations have long-term commitments abroad. Moreover, RTIs sell their services to customers from an array of industries, which suggests that these organisations are not limited to a single sectoral base but provide competences in specific technologies;
- 2** While other business services have been introduced to provide additional income, technology and innovation services remain the strategic focus;
- 3** RTIs are innovative organisations in their own right. RTIs engage in new service development and assess their innovation capabilities to be of national and international standards.

This is pilot study and further research is necessary in four areas. First, with respect to the organisations discussed in this paper, complimentary case-work would highlight the managerial roles, which facilitated the development of RTI capabilities. For instance, how did UK RTIs adapt to national and global market conditions while retaining strategic prowess in applied research? Second, a larger sample would sharpen the conclusions. This would include wider participations from the research and development business sector including knowledge intensive business services (KIBS). Third, an international set of RTIs could be profiled. This would illuminate and contrast different institutional approaches to science and technology policy. Finally, as much as this was an exercise to profile RTIs, this study should contribute to a large body of work that has been building around innovation systems. The next stage would investigate the users for technology and innovation services, particularly how RTIs can contribute to the upgrading of competences in the future.

## Appendix 1: Methodology

A questionnaire was posted to 40 UK RTIs in 2009. The targeted population was drawn from the 36 members of the UK Association of Independent Research and Technology Organisations (AIRTO), which include private limited companies, companies limited by guarantee (Not for Profit) and a University technology centre. AIRTO member organisations have also participated in previous studies (see Arnold, Rush, Bessant and Hobday 1998; Bessant and Rush 1995; Howells 2006). A further four organisations were selected from the wider contract research community (two private limited companies and two Government Institutions) which matched the activities of the AIRTO membership.

The survey questions were drawn from the management and strategy literature with particular attention given to industrial organisation (Porter 1990), resource structure of the firm (Grant 1991), the functions and activities associated with innovation, (OECD 2005) and innovation capabilities (Tidd, Bessant and Pavitt 2005). A mix of nominal, ordinal and scale questions were used. A statistician specialising in questionnaire design and an expert in innovation studies reviewed the survey. Finally, the questionnaire was trialled with a senior manager in one UK RTI. In total, 15 organisations completed the questionnaire for a response rate of 38%. Table 10 and Table 11 illustrate the breakdown of the sample by organisation type and employee band size.

**Table 10:** Sample size by organisation type

	Frequency	Per cent (%)
Private Firms	7	47
Not for Profit RTIs	5	33
Government Institutions	2	13
Universities	1	7
<b>Total</b>	<b>15</b>	<b>100</b>

**Table 11:** Sample size by employee band size

Number of employees	Frequency	Per cent (%)
Small (1-49)	6	40
Medium (50-49)	4	27
Large (>250)	5	33
<b>Total</b>	<b>15</b>	<b>100</b>

## Appendix 2: AIRTO Membership In 2009

Aircraft Research Association Limited  
ARUP Research and Development  
BMT Group Limited  
BRE Group  
The Building Services Research and Information Association  
Campden BRI  
CERAM Research Ltd  
Cocoa Research UK Ltd  
City University London  
CIRIA  
E-Synergy Ltd  
FIRA International Ltd  
Halcrow Group Ltd  
Health & Safety Laboratory  
HR Wallingford Group Ltd  
ITRI Limited  
Leatherhead Food International  
LGC  
MIRA Ltd  
The Motor Insurance Repair Research Centre  
NAMTEC (National Metals Technology Centre)  
The National Computing Centre Limited  
National Physical Laboratory  
National Nuclear Laboratory  
Pera Group  
The Paint Research Association  
QinetiQ Group plc  
Quotec Limited  
SCI  
Smithers Rapra Technology Limited  
Thames Innovation Centre Ltd  
The Scotch Whisky Research Institute  
The Smith Institute  
TRADA Technology Limited  
TWI Ltd  
University of Surrey

Source: AIRTO website (AIRTO 2009)

## References

- Abramovitz, M. (1986) 'Catching Up, Forging Ahead, and Falling Behind.' *The Journal of Economic History* 46(2): 385-406.
- AIRTO. (2009) 'Official AIRTO website.' Retrieved 1 June 2009, from [www.airto.co.uk/](http://www.airto.co.uk/)
- Arbussa, A. and Coenders, G. (2007) 'Innovation activities, use of appropriation instruments and absorptive capacity: Evidence from Spanish firms.' *Research Policy* 36(10): 1545-1558.
- Arnold, E., Rush, H., Bessant, J. and Hobday, M. (1998) 'Strategic planning in Research and Technology Institutes.' *R&D Management* 28(2): 89.
- Berry, W. L., Hill, T. J. and Klompmaker, J. E. (1995) 'Customer-driven manufacturing.' *International Journal of Operations & Production Management* 15(3): 4-15.
- Bessant, J., Kaplinsky, R. and Lamming, R. (2003) 'Putting supply chain learning into practise.' *International Journal of Operations & Production Management* 23(2): 167-184.
- Bessant, J. and Rush, H. (1995) 'Building bridges for innovation: the role of consultants in technology transfer.' *Research Policy* 24: 97-114.
- Caffyn, S. and Grantham, A. (2003) 'Fostering Continuous Improvement within new product development processes.' *International Journal of Technology Management* 26(8): 843-856.
- Centre for the Study of Industrial Innovation (1972) *Research associations: the changing pattern*. London, Centre for the Study of Industrial Innovation.
- Chesbrough, H. W. (2003) *Open innovation: the new imperative for creating and profiting from technology*. Boston, Mass., Harvard Business School; Maidenhead: McGraw-Hill.
- Chesbrough, H. W. (2006) *Open business models: how to thrive in the new innovation landscape*. Boston, Mass., Harvard Business School; London: McGraw-Hill, distributor.
- Cohen, W. M. and Levinthal, D. A. (1989) 'Innovation and Learning: The Two Faces of R&D.' *The Economic Journal* 99(397): 569-596.
- Collis, D. J. (1994) 'Research note: How valuable are organizational capabilities?' *Strategic Management Journal* Special Issue 15: 143-152.
- Di Benedetto, A. (1999) 'Identifying the Key Success Factors in New Product Launch.' *Journal of Product Innovation Management* 16(6): 530-544.
- DTI (2003) *Competing in the global economy: the innovation challenge*. London, Department of Trade and Industry.
- DTI (2006a) *The Impact of Networks on the Learning and Skills Development of Businesses*. York Consulting, Department of Trade and Industry.
- DTI (2006b) *Innovation in the UK: Indicators and Insights (No. 6)*. *DTI occasional paper series*. London, Crown Copyright.
- DTI (2006c) '4th Community Innovation Survey Results.'
- Grant, R. M. (1991) 'The Resource-Based Theory of Competitive Advantage: Implications for Strategy Formulation.' *California Management Review* 33(3): 114-135.
- Hargadon, A. B. and Sutton, R. I. (1997) 'Technology brokering and innovation in a product development firm.' *Administrative Science Quarterly* 42: 718-749.

- Hargadon, A. B. (1998) 'Firms As Knowledge Brokers: Lessons in pursuing continuous innovation.' *California Management Review* 40(3): 209-227.
- Howells, J. (2006) 'Intermediation and the role of intermediaries in innovation.' *Research Policy* 35(5): 715-728.
- Iansiti, M. (1995) 'Technology integration: Managing technological evolution in a complex environment.' *Research Policy* 24(4): 521-542.
- Katz, R. and Allen, T. J. (1985) 'Project performance of project groups in the R&D matrix.' *Academy of Management Journal* 29(1): 67-87.
- Kline, S. and Rosenberg, N. (1986) An overview of innovation. *The Positive Sum Strategy: Harnessing Technology for Economic Growth*. Landau, R. and Rosenberg, N.. Washington, DC, National Academy Press: 275-304.
- Laursen, K. and Salter, A. (2006) 'Open for innovation: the role of openness in explaining innovation performance among U.K. manufacturing firms.' *Strategic Management Journal* 27(2): 131-150.
- Lundvall, B-Å. (1992) *National systems of innovation: towards a theory of innovation and interactive learning*. London, Pinter.
- Malerba, F. (2002) 'Sectoral systems of innovation and production.' *Research Policy* 31(2): 247-264.
- Mantel, S. J. and Rosegger, G. (1987) The role of third-parties in the diffusion of innovations: a survey. *Innovation: Adaptation and Growth*. Rothwell, R. and Bessant, J.. Amsterdam, Elsevier: 123-134.
- Nelson, R. R. (1994) 'The Co-evolution of Technology, Industrial Structure, and Supporting Institutions.' *Industrial Corporate Change* 3(1): 47-63.
- OECD (2005) *Oslo manual: guidelines for collecting and interpreting innovation data*, (3rd ed.). Paris, OECD Publishing.
- OECD (2008) *Main Science and Technology Indicators*. Paris, OECD Publishing.
- ONS (2008) UK Business: Activity, Size and Location – 2008. UK Office for National Statistics, Office for Public Sector Information.
- Piore, M. and Sabel, C. (1984) *The Second Industrial Divide*. New York, Basic Books.
- Porter, M. E. (1990) *The competitive advantage of nations*. London, Macmillan.
- Readman, J. (2001) The supply of explicit research, technology and innovation services in the UK. *RISE project: RTOs in the service economy*. European Commission DG Research under the TSER programme. Brighton, UK, Centre for Research in Innovation Management.
- Rothwell, R. (1994) 'Towards the Fifth-generation Innovation Process.' *International Marketing Review* 11(1): 7-31.
- Rush, H., Hobday, M. Bessant, J. Arnold, E. and Murray, R. (1996) *Technology institutes: strategies for best practice*. London, International Thomson Business Press.
- Tidd, J., Bessant, J. R. and Pavitt, K. (2005) *Managing innovation: integrating technological, market and organization change*, (3rd ed.). Chichester, John Wiley and Sons.
- Ulwick, A. W. (2002) 'Turn customer input into innovation.' *Harvard Business Review* January: 91-97.
- Voss, C. A., Chiesa, V. and Coughlan, P. (1994) 'Developing and Testing Benchmarking and Self-assessment Frameworks in Manufacturing.' *International Journal of Operations & Production Management* 14(3): 83-100.





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