scottish science advisory council

Business R&D in Scotland – A Missing Link

SCIENCE AND ENGINEERING DELIVERING THE FUTURE

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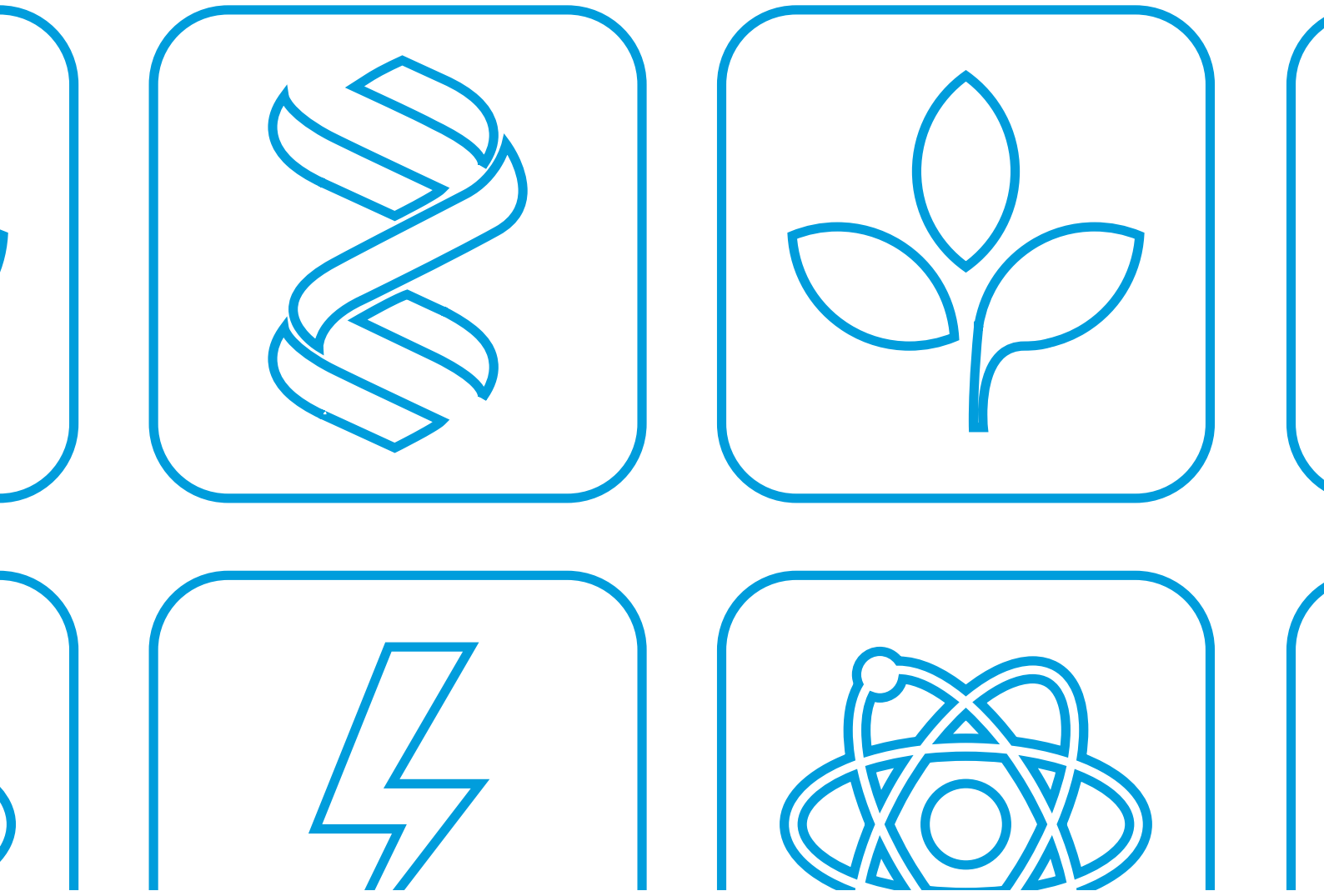

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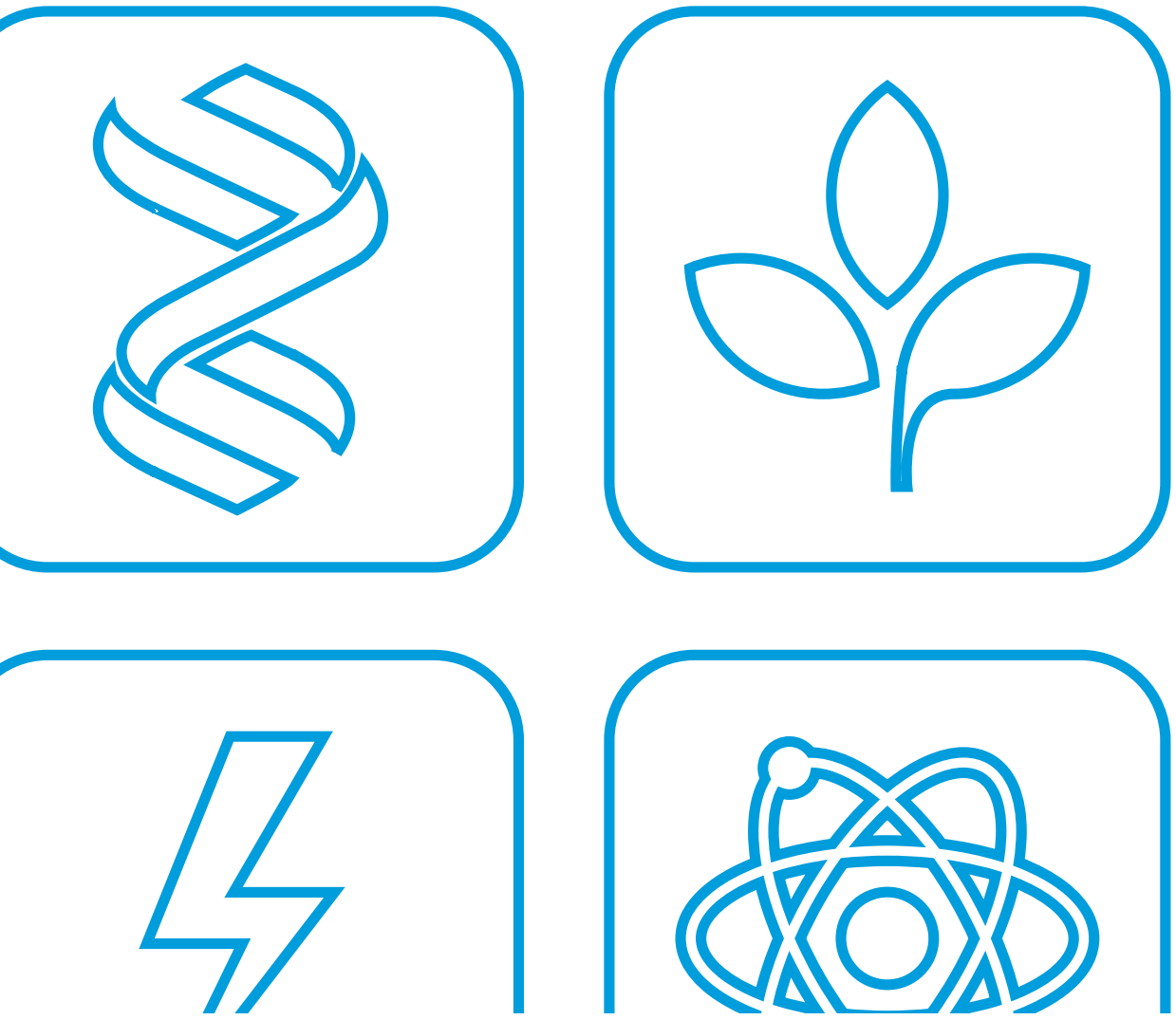

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The Scottish Science Advisory Council

The Scottish Science Advisory Council (SSAC) is Scotland's highest level advisory body for science, engineering and technology. The SSAC is an independent advisory body providing advice and recommendations on science strategy, policy and priorities to the Scottish Government's Chief Scientific Adviser (CSA). It is a broadly-based group, including both practitioners and users of scientific innovation.

Terms of Reference

The terms of reference for the Scottish Science Advisory Council are to:

- Advise the Scottish Government's Chief Scientific Adviser on a broad range of scientific issues and science-related policies that will grow our economy and raise our quality of life and will further enhance Scotland as a science nation.

The SSAC will provide advice to the CSA on science strategy, policy and priorities to allow the Scottish Government to make effective use of available scientific advice, knowledge and techniques in formulating and implementing policies to support the full range of its objectives.

The SSAC will take a medium- to long-term, horizon-scanning, strategic view in formulating its advice.

The SSAC has a purely advisory role and does not direct any research expenditure.

Executive Summary

It is widely recognised that business innovation is a driver of economic growth and that research and development (R&D) in business is a driver of innovation, yet Scotland is characterised by a relatively low level of business R&D compared to the rest of the UK and other comparable countries. In contrast, Scotland's Universities are recognised as highly competitive earners of research income and for the quality of their research.

The outputs of Scotland's universities (research, consultancy, trained PhD graduates) are not being captured by Scottish industry, which in turn exerts little influence on the research undertaken in academia. This mismatch between supply of academic research output and demand from industrial R&D is at least a missed opportunity whose correction could improve our economic performance.

This report by the Scottish Science Advisory Council concludes our study of business R&D in Scotland. Based on our own work and commissioned research, it outlines a number of factors which influence the apparently small capacity of the business R&D base and recommends a number of actions to the Scottish Government and its agencies.

We find that there are historical and structural reasons for a low level of business R&D, but also weaknesses in measurement which has not kept pace with the modern trend of outsourcing research and development activities to third parties. We have found that incentives for research could be better promoted and that there is a need for education and training to correct for historical deficiencies in business R&D management expertise.

SSAC recommends that:

1. Contradictory findings from recent policy research on the capabilities of the Scottish business base should be resolved.

2. Business should be encouraged to recognise the value of investment in R&D.

3. The Scottish Government should ensure that its schemes to incentivise business R&D are effective.

4. The Scottish Government should strengthen the pipeline of support mechanisms.

5. Limits on the expansion of Knowledge Transfer Partnership funding in Scotland should be addressed to further encourage links between university and business research.

6. Proof of concept type support should be expanded to include business innovation.

7. The Scottish Government, together with Scottish Enterprise, should put in place measures to enhance management skills in business R&D.

8. A toolkit to support decision making by business R&D managers and encourage R&D investment should be introduced.

9. The link between R&D and innovation in the service sector should be better understood by further research.

10. A public forum for information dissemination and consensus building to encourage greater investment in business R&D should be established, perhaps through the Royal Society of Edinburgh.

Introduction

1. Scotland's academic research base performs strongly on a number of international comparators, including: publications per head of population, research income share, citation output, licensing of technology and spinout creation. A recent report on the international impact of Scotland's research base confirms its strength in terms of achievement, productivity and efficiency[1]. Expenditure on research in the higher education sector stood at 12.4% of the UK total in 2005 with a total spend of £688m or 0.7% of GDP, comfortably leading the other countries of the UK on a population basis.

2. By contrast, Business R&D conducted in Scotland under-performs the rest of the UK, contributing only 0.56% of GDP compared with 1.08% for the UK as a whole in 2006[2]. Overall, Business Enterprise Research & Development (BERD) expenditure in Scotland was £584m in 2005, or 4.4% of the UK total.

3. The Economic Strategy of the Scottish Government[3] sets out the Purpose of Government and indicates how it will support businesses and individuals to deliver its objectives by "*creating a more successful country, with opportunities for all of Scotland to flourish, through increasing sustainable economic growth*". It intends to increase Scotland's GDP growth rate to the UK level by 2011. Among the strategic approaches to be taken, the Scottish Government intends to take a broader approach to innovation, moving beyond viewing innovation as the domain of science and technology but explicitly intending to focus on a stronger link between Scotland's research base and business innovation, and addressing the low level of business R&D.

4. This recognition of the importance of business R&D is reflected in the report of the Joint Future Thinking Taskforce on Universities[4] which poses a number of questions related to increasing the absorptive capacity for research of companies in Scotland

1 Metrics for the Scottish Research Base, Evidence Report for the Scottish Government 2008. http://www.scotland.gov.uk/Resource/Doc/981/0055654.pdf

2 Business Enterprise Research & Development Scotland 2006, The Scottish Government 2008. http://www.scotland.gov.uk/Resource/Doc/981/0055565.pdf

3 Government's Economic Strategy, The Scottish Government 2007. http://www.scotland.gov.uk/Publications/2007/11/12115041/0

4 New Horizons: responding to the challenges of the 21st century, Joint Future Thinking Taskforce on Universities 2008. http://www.scotland.gov.uk/Resource/Doc/82254/0069165.pdf

and proposes that there is a need to address these issues to promote engagement between universities and business.

5. SSAC set out to attempt to understand the various factors that impact on the volume of industrial R&D in Scotland. Although SSAC's membership most strongly represents the science base, restructuring of the Council increased industrial representation and motivated it to focus on and address this issue.

6. The level of industrial R&D activity in Scotland not only influences economic growth but also impacts on the academic research base by:
   - Providing a market for knowledge transfer from academic research;
   - Creating postdoctoral employment opportunities for PhD graduates (and graduates with specific skills from certain disciplines, e.g. science and engineering), retaining highly-skilled individuals in Scotland; and
   - Supplying a source of informed guidance and support for strategic or applied academic research activities.

7. Industrial R&D is therefore mutually beneficial to the academic research base and the Scottish economy. This report sets out some of the issues underpinning the apparent weakness of business R&D in Scotland and makes a number of recommendations for improving our understanding and measurement of BERD, as well as increasing capacity to grow industrial research.

8. SSAC has previously published a report on knowledge transfer between the science base and business[5]; the present study aimed to avoid covering the same ground, concentrating on the 'marketplace' for Scottish knowledge transfer.

Methodology

9. An SSAC working group began by conducting its own limited desk research to shape its study. It held a one-day workshop, *Research and Development: Science Base to Business* at the Royal Society of Edinburgh in November 2005. The specific aims of the workshop were to examine: how to improve university-industry interactions in Scotland; how government R&D support could be best focused to benefit the industrial base in Scotland; and how the science base could assist

5 Knowledge Transfer: Science to Scottish Businesses, SSAC, 2004

Scottish industry to grow its overall value leading to enhanced economic development in Scotland.

10. A summary of the opinions expressed by speakers and member of the audience at the workshop is included in Appendix 1 to this report.

11. Using the outputs from the workshop as a guide, a commissioning brief was developed for a consulting team to conduct further desk research and primary research through interviews with stakeholders under the Working Party's guidance. SQW Ltd were appointed to this role and carried out their task over the period April – September 2006.

12. In addition to extensive desk research, SQW carried out consultations with a number of individuals in the public and private sectors, whose inputs are gratefully acknowledged. These include consultees drawn from the Scottish Government; Scottish Enterprise; the Scottish Funding Council's Knowledge Transfer and Innovation Task Group; the commercialisation function within a university research school; the technology and innovation functions within major Scottish banks, as well as companies in the supply chain of the banking sector.

13. The output from this phase was published as a set of reports and recommendations (referred to as the *working papers*) on the internet[6] for consultation and feedback. Attendees at the November 2005 workshop in particular were invited to comment on the findings.

14. This report summarises the work undertaken and makes a number of recommendations which the SSAC believes will enhance research and development in Scottish companies.

Concepts and Definitions

15. It is important to fully understand the definitions that apply to business R&D as they impact on data gathering and support measures. The distinction between R&D and innovation and the relationship of one to the other, are also crucial to our understanding of the state of business R&D in modern economies, including the

6 Patterns in business R&D, SQW for the SSAC, 2006
http://www.scottishscience.org.uk/documents/Patterns%20of%20Business%20R&D.pdf

economy of Scotland. Chapter 3 of the SSAC working papers explores this subject in greater detail – the following highlights cover the key points.

16. Research and Development, and related concepts, follow internationally agreed standards defined by the Organisation for Economic Cooperation and Development (OECD) and published in the 'Frascati' Manual[7]. R&D is defined as "*creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of the stock of knowledge to devise new applications".* The definition excludes activities such as market research, most software development, routine testing, quality control and artistic design work.

17. Statistics on Business Enterprise Research and Development (BERD) expenditure in the UK limits R&D to that undertaken within business enterprises (intra-mural research, irrespective of the source of funding) and excludes R&D undertaken in higher education institutions (HEIs) or government establishments (even if funded by business)[8].

18. Innovation on the other hand may be defined simply as *the "successful exploitation of new ideas"*[9]*.* Innovation therefore is not restricted in terms of process or of outcome to science and technology matters, and not to R&D. R&D is but one possible input to innovation. Invention may be a pre-requisite for certain types of innovation, but it is only when the invention is exploited commercially that it results in 'innovation' and starts to yield economic benefits.

19. There is an important distinction to be drawn between *radical* and *incremental* innovation. The former represents something new: the latter represents an improvement to something that already exists. Radical innovations have the potential to cause very significant and rapid transformations in markets, whereas the effects of incremental innovation may be felt more slowly. However, the cumulative business and economic impact over time of the incremental innovation may be just as significant.

7 Frascati Manual 2002: Proposed Standard Practice for Surveys on Research and Experimental Development http://www.oecd.org/document/6/0,3343,en_2649_34451_33828550_1_1_1_1,00.html

8 Business Enterprise Research and Development (BERD) http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=8206

9 http://www.berr.gov.uk/dius/innovation/index.html

20. Linked to the above, innovation may be wholly novel, new to an industry, new to a market or new to a firm. Degree of novelty can be an important eligibility criterion for businesses seeking public sector grants and other incentives to support R&D and related innovation.

Summary of Findings and Recommendations

21. It is axiomatic that industry is motivated, to different degrees, by innovation. Members of the working party were keen to point out, however, that the linear model of innovation in which research in Universities was taken up by an industrial research laboratory to be developed into a commercial product and sold into the market place no longer accounts for the majority of innovative products, processes and services sold by industry. The SSAC is concerned that this appears to be the model that government agencies continue to assume in devising policies and interventions intended to promote economic growth. Of course, it is valid in restricted circumstances – in particular, as a model for spinout creation from the academic research base – and in these same circumstances the policies and interventions themselves remain vital.

22. A considerable body of evidence now supports 'open' or 'networked' models of innovation in which new products, processes and services are stimulated internally, by the needs of customers, the behaviour of competitors and the availability of new technologies from other companies; and satisfied by creative behaviours within a company, such as design or process enhancement, that cannot be categorised or measured as research.

23. Research in the Frascati sense may be conducted or commissioned by a company as an input to the innovation process but is not essential to it. Consequently, the relationship between innovation in modern industry and scientific research carried out in Universities is not essential. Innovation systems and academic research systems can coexist independently of one another unless innovation in a particular sector is dependent on academic research inputs. This finding is consistent with Lambert's observation that the growth of industrially-funded research in UK Universities is constrained by demand, not by academic research capacity despite the relative success of the UK economy[10]. NESTA has coined the term 'hidden

10 Lambert Review of Business-University Collaboration, HM-Treasury, 2003
http://www.hm-treasury.gov.uk/consultations_and_legislation/lambert/consult_lambert_index.cfm

innovation' to explain the apparent paradox between the UK's relatively poor level of expenditure on industrial R&D and the success of the UK economy. Its case studies reinforce an understanding of innovation based on inputs from sources other than scientific research. The innovation is hidden only in the sense that it is not measured by business R&D statistics[11].

24. Although our understanding of the relationship between innovation and research has evolved from in-house to open and networked approaches, methods of measuring research in industry have not moved-on at the same pace. BERD measures in-house R&D only, and R&D tax credits reward internal expenditure only. Outsourced R&D, especially work commissioned from Universities, would not appear as business research. **The SSAC believes that the measurement of R&D in industry needs to change to reflect current practice and modes of working.**

25. Chapter 4 of the SSAC working papers reviews the state of business R&D in Scotland, and notes some interesting differences of opinion on the state of innovation in Scottish industry. In particular, analysis of the 2003 Community Innovation Survey[12] carried out on behalf of the Scottish Government suggests that novel innovation – the introduction of products and services entirely new to the market – is relatively strong in spite of the low average R&D spend. **Speculation that some Scottish companies are making effective use of the academic research base in support of novel innovation merits further study even if it appears to be based on the outmoded linear model.** We summarise this work in Chapter 5.

26. Chapter 4 also examines research intensity in different industrial sectors. It is well known that research intensity (the ratio of R&D spend to turnover) varies from industry to industry. In both Scotland and the rest of the UK the pharmaceutical industry has the highest research intensity. Indeed Scotland's pharmaceutical sector outperforms the UK on this measure and is responsible for around half of the growth of Scotland's business R&D over the period 1997-2002. However, business research intensity falls more rapidly in Scotland than elsewhere in the UK so that in

11 Hidden Innovation Report, NESTA, 2007
http://www.nesta.org.uk/informing/policy_and_research/highlights/hidden_innovation.aspx

12 The Community Innovation Survey: An Analysis for Scotland, Scottish Government, 2007
http://www.scotland.gov.uk/Topics/Statistics/publications/CISScotland/reportpdf

general, companies in the most research intensive sectors spend less on R&D in Scotland than the same, or other companies, elsewhere in the UK. **These findings are disappointing, but again merit further study for a full explanation.** A recent report highlights that attempts to encourage higher levels of innovation (and related policy measures) need to be sensitive to the different innovation emphases and opportunities across sectors. Whilst welcome investments have been made in Scotland, aimed at improving the transfer of pre-competitive technologies from the science base and supporting nascent industries in areas including biotechnology and optoelectronics, one of the conclusions in the report states that, improving innovation performance in existing industries is key to improving the performance of the Scottish economy[13].

27. Historically, few science-based industries originated in Scotland and consequently have not migrated research laboratories here. The aerospace industry, which ranks second in the UK, carries out most of its research outwith Scotland. The presence in Scotland of sectors such as electronics has been driven by economic development policies concentrating on maximising job creation by inward investment. Research and development functions have rarely followed. Recent attempts to bring higher value electronics jobs to Scotland with stronger connections to University research foundered in the aftermath of the dot.com collapse. Some aspects of the low R&D spend in industry can therefore be attributed to historical factors and the geography of industrial R&D in the UK, rather than to a peculiar reluctance to invest in research by Scottish-based companies.

28. The research intensity in Scotland's pharmaceutical industry and its recent rapid growth demonstrate that new science-based industries can be grown and developed in Scotland by a combination of inward investment, indigenous growth and university spinouts in such a way that academic research and company innovation are strongly coupled. In 2005, 20 per cent of Europe's life science initial public offerings (IPOs) were Scottish[14]. **This industry provides a success story for research-based innovation that would benefit from deeper understanding and emulation in other emerging technologies.**

13 The Community Innovation Survey 4: Profiling Scotland's Innovation Performance, Scottish Governement, 2007 http://www.scotland.gov.uk/Publications/2007/07/04110926/0

14 Life Sciences Scotland http://www.scottish-enterprise.com/se/life_sciences/life-sciences-in-scotland.htm

29. Chapter 6 explores innovation in the Scottish financial services sector in more detail. From Q1 2000 to Q1 2007 the financial services industry in Scotland grew by 60%, while the overall Scottish economy grew by 14%. By contrast the UK financial services industry grew by 47% in the same period. Financial services now account for 10% of Scottish jobs and contribute £7bn (6%) of Scottish GDP[15]. Although we were unable to disaggregate financial services research spend from the general services sector, a very small proportion of the latter is spent in Scotland and it is likely that financial services research spend follows the same geographic pattern. For example, the Royal Bank of Scotland's Innovation Unit is based in London probably because of its proximity to the City and the major capital markets.

30. The Financial Services sector is clearly innovative, but as our consultations demonstrated, the primary driver of innovation is market opportunity rather than technology push. Some market opportunities stimulate internal innovation, but where new technology is a crucial factor it is more likely to be bought-in than developed internally. It would be pointless to expect this sector to increase its research spend to a national norm, but investing in research-intensive sectors that create the technologies on which new services might be built not only creates new markets for those sectors but also enhances the competitiveness of the service sector. Our working papers examine two examples of innovation by Scotland-based technology companies (ECEBS and NCR) which directly impact on the financial services sector. Such indirect acquisition of new technology, following the 'open innovation' model, suggests that Scotland could enhance the competitiveness of one of its most important industries by supporting R&D in its technology supply chain. **Given the importance of the service sector to the Scottish Economy SSAC believes that a better understanding of supply chain linkages between the technology and the service sectors is vital.**

31. Chapters 12, 13 and 14 of our working papers explore industry R&D incentive schemes in other countries. We examined in detail the Israeli innovation scheme and noted the success of their one-stop shop arrangement for supporting innovation and R&D in industry. In Scotland, the situation is more complex and potentially more confusing with Scottish Enterprise and the Scottish Government responsible for different streams of support. We considered that R&D support aimed at businesses and industries should be channelled through a single

15 Scottish Financial Enterprise – http://www.sfe.org.uk/

organisation in Scotland, probably Scottish Enterprise. **The SSAC supports the move to a new streamlined grant process through, SMART:Scotland and the Scottish Business Grants web portal**[16]**.**

32. We also noted the Israeli strategy of supporting R&D only in companies which were already going concerns. Whilst we do not recommend switching wholesale to this approach we do believe existing companies need encouragement to invest in research and should have equal access to support funding. There is evidence from the success rates in SMART awards, for instance, that start-ups are more successful at gaining R&D support funding than established businesses perhaps because they more obviously meet research-driven selection criteria. The SSAC is supportive of the aims of ITIScotland in relation to identifying and commercialising technology-based intellectual assets across three significant market sectors by actively supporting longer-term R&D in established companies. We strongly support this mechanism for its market-driven approach to procurement of research from industrial and academic teams and believe that similar mechanisms, such as the Small Business Innovation Research[17] (SBIR) pioneered successfully in the USA should be adopted to encourage market-led research in Scottish industry. The SSAC was encouraged to note that in *The Race to the Top*[18], Lord Sainsbury recommended that the Small Business Research Initiative (SBRI) scheme should be reformed to more closely resemble the successful US scheme, and that this is being driven forward by the Technology Strategy Board.

Understanding, Promotion and Incentives

33. The argument which links levels of investment in R&D to innovation, to productivity and then to enhanced economic performance as measured by GDP is widely used and underpins much analysis of the under-performance of the Scottish economy when compared to OECD norms.

34. In line with UK-wide goals, the Scottish Science Advisory Council supports the UK Government's 10-year Science and Innovation Investment Framework published in

16 SMART:Scotland – http://www.scottishbusinessgrants.gov.uk/rsa/999.html

17 Small Business Innovation Research – http://www.sbir.gov/

18 The Race to the Top: A Review of government's science and innovation policies – http://www.hm-treasury.gov.uk/d/sainsbury_review051007.pdf

June 2004[19] which sets the goal of increasing business and public investment in R&D as a proportion of GDP to 2.5% by 2014. This UK Framework set a goal for business expenditure in R&D (BERD) as a share of GDP of 1.7%.

35. In various guises, the view has often been expressed that the Scottish business base fails to exert a "pull" on the research excellence in the Scottish science base. Some have expressed this as a lack of so called "absorptive capacity" in the business base. This view has been restated recently in the findings of the work on the Scottish Innovation System by the Universities of Aston and Cardiff[20]. However, the analysis of the Community Innovation Survey for Scotland 3[21] (CIS3) offers a quite different view: the authors of this report state "*Our analysis suggests … Scottish firms' greater utilisation of external resources as sources of innovation inputs*", i.e. they absorb from their wider environment and according to this report, appear to do so despite their undoubtedly relatively low level of spend on R&D.

36. CIS4[22] characterises Scotland's innovation performance as, "*worse than the best, but much like the rest*." This report recognises two trends, the growth in innovation networking and the growing importance of knowledge intensive and financial services. In terms of innovation networking, Scottish firms appear more likely to have co-operated with both the public and private knowledge infrastructures and were more likely to have invested in all categories of innovation-related expenditure, than non-co-operating innovation active firms.

Recommendation 1: **Resolving apparently contradictory findings from recent policy research on the capabilities of the Scottish business base.**

37. It is important that a robust and clear evidence base is put in place to inform and guide policy implementation in the area of business R&D. The Scottish Government with Scottish Enterprise should ensure that apparently mixed messages about the innovative behaviour and capabilities of the Scottish business base are re-examined and resolved as far as possible. This could be done in the context of an analysis of the recently published UK data for CIS4.

19 Science & innovation investment framework 2004-2014, ,HM-Treasury, 2004 http://www.hm-treasury.gov.uk/spending_review/spend_sr04/associated_documents/spending_sr04_science.cfm

20 The Scottish Innovation System: Actors, Roles and Actions, Scottish Executive, 2006 http://www.scotland.gov.uk/Publications/2006/01/18151934/0

21 Community Innovation Survey: An analysis for Scotland (CIS3), Scottish Executive, 2007 http://www.scotland.gov.uk/Resource/Doc/981/0007446.pdf

22 The Community Innovation Survey 4: Profiling Scotland's Innovation Performance, Scottish Executive, 2008 http://www.scotland.gov.uk/Publications/2007/07/04110926/0

38. There is a perceived dearth of promotional and support activity (beyond project grants) for "R&D" relative to business "innovation" more generally. A number of public sector initiatives available to the Scottish business-base seek to encourage and support business investment in R&D and address associated market failures. In addition to grant schemes (e.g. SCIS, SMART etc.), tax relief for R&D expenditure has been available in the UK since 2000, initially for SMEs and since 2002 for larger companies. The R&D Tax Credit is designed to incentivise and reward firms investing in R&D to enhance their performance and ultimately contribute to the competitiveness of the UK.

39. In a UK-wide survey of businesses conducted by Deloitte in 2006, it was found that fewer than 50% of eligible smaller firms were taking advantage of the R&D Tax Credit. Furthermore, of those firms responding to the survey that had failed to claim, around 25% were reported as being unaware of the scheme's existence.

40. The Scottish Government has put in place a so-called "pipeline of support" for R&D and innovation for the Scottish business base. Although R&D grant schemes managed by the Government are focused on "new to the market" innovation, we would argue the merits of encouraging, in addition, a wider cross-section of companies to engage in R&D, not least because "undertaking R&D is normally a pre-requisite before firms participate in collaborative projects with the science base". Also, the analysis of the Community Innovation Survey results for Scotland indicate that Scotland's innovation performance lags behind the average of all UK areas in terms of investment in extra-mural R&D per employee. "Entry level" schemes to support R&D should be encouraged and given a high profile.

Recommendation 2: Recognise the value of investment in R&D.

41. Although R&D is only one input to business innovation and productivity performance, given the importance accorded to it for Scotland there would be merit in the Scottish Government establishing a high profile, integrated and nationally agreed action plan focused on promoting the business value of investment in R&D. This should be complemented by existing and where appropriate, targeted new business support interventions (including interventions that do not include provision of financial support for R&D projects), by a cadre of expert advisors on R&D management for businesses, and tracked by statistics on activities, outputs and outcomes to measure progress towards the policy goal of increased BERD.

Recommendation 3: Ensuring effective incentives.

42. Given its aim of encouraging firms to invest in R&D and the importance of smaller companies to the Scottish economy, it is recommended that the Scottish Government analyse the take-up and success, or otherwise, of the R&D Tax Credit scheme in Scotland in incentivising additional investment in research and development.

Recommendation 4: Strengthening the pipeline of support.

43. The Scottish Company Innovation Support Scheme (SCIS), managed by Scottish Enterprise, provides support to businesses for R&D, market research and product launch. It is aimed at R&D to support innovation that is "new to the firm". Anecdotally, it appears that SCIS is given a relatively low profile in the Scottish business base. We recommend that the Scottish Enterprise re-examines the balance between supply and demand (and opportunity) relating to SCIS and re-assess whether the present access to SCIS is optimal given the findings.

Recommendation 5: Address the limits on expansion of KTP in Scotland.

44. We also understand that Scotland performs well relative to other parts of the UK in terms of take-up of Knowledge Transfer Partnerships (KTP) support. Again, we suggest that there is merit in the Scottish Government re-assessing the balance between supply and demand (and opportunity) for KTPs in Scotland and whether the present provision is optimal given the findings.

45. It has been brought to our attention that proposals seeking R&D grant support emerging from the SE Proof of Concept Programme tend in the main to be strong candidates for support – they tend to be "SMART-investment" ready.

Recommendation 6: Expansion of Proof-of-Concept-type support.

46. Subject to constraints that may be placed on investment by European State Aid rules, we propose an investigation of the needs/opportunities to develop innovative products and processes of value from sectors of the economy other than the Universities, Research Institutes and NHS. The feasibility and attractiveness of proof of concept-type support for other sectors of the economy should be assessed.

Management Capacity and Capability

47. In its evidence to the Scottish Parliament's Business Growth Enquiry[23], SCDI stressed the importance of effective management skills in the Scottish business base, considering it essential that Scottish business leaders "have the knowledge and insights to make decisions on investment, R&D innovation and employee development". The Scottish Innovation System: Actors, Roles and Actions Report stated that, "*A very consistent picture was drawn of the relative thinness of the SME sector in Scotland in terms of scientific and managerial competence ….*". The analysis of the Third Community Innovation Survey (CIS3) results for Scotland indicates that among some positive messages about the innovation performance of the Scottish business base, it points to poorer performance with respect to the UK average in terms of organisational innovation, such as advanced management techniques. CIS4 suggests that Scottish firms are relatively more likely to have implemented new management techniques (compared to the rest of the UK), but all Scottish firms appear less likely to have implemented change in corporate strategy, with changes in organisational structure and marketing more common than changes in corporate strategy.

48. The challenge is not new, nor purely a Scottish one. The Council for Science and Technology (CST) found that "many UK technology-based businesses, both large and small, are finding it increasingly hard to find top quality, highly qualified people with CVs bridging the two worlds of business and research to fill senior positions"[24].

49. It should be remembered that there is no fundamental challenge in creating managers capable of bridging between science/technology and business. Scientifically trained Scots frequently head-up multi-billion dollar R&D operations in multinational companies. On a small scale, the RSE/SE Enterprise Fellowships Scheme has demonstrated that young scientists can rapidly transition from the lab to becoming effective managers, capable of building science-based, R&D intensive enterprises[25].

23 Business Growth the next 10 years, Enterprise and Culture Committee, Scottish Parliament, 2005 http://www.scottish.parliament.uk/business/committees/enterprise/reports-06/ecr06-05-Vol01-00.htm

24 Technology Matters, Council for Science and Technology, 2000 http://www2.cst.gov.uk/cst/reports/files/technology-matters/mainrep.pdf

25 Scottish Enterprise/RSE Enterprise Fellowships http://www.rse.org.uk/research_fellowships/scot_ent.htm

50. This recommendation is made in the context of a general awareness of business support interventions targeted at, e.g. marketing, exporting, managing intangible assets, lean management, etc., but we are not aware of management development initiatives for SMEs targeted at business decisions associated with R&D, its management and where appropriate, its procurement.

51. Developing the knowledge and insights to be able to make well-informed (de-risked) investment decisions on R&D and innovation is difficult to acquire, either through formal business training or experience.

52. R&D oriented management development programmes could potentially have positive impacts in the short-term, but a more rapid turn-around can only be realised by attracting management talent with these skills into Scotland. This is a more fundamental challenge, especially given the lack of critical mass of R&D-intensive businesses in almost all sectors, which is a disincentive to executive talent relocating. New approaches are required, beyond seeking to exploit the GlobalScot[26] network of Scots now working overseas, mostly in North America.

Recommendation 7: Management Capacity and Capability.

53. The Scottish Government and Scottish Enterprise should undertake a needs/opportunities assessment for enhancing business management skills directed towards utilising and exploiting R&D investments as an input to business competitiveness. This is likely to involve two strands of investigation:
    - enhancing capability amongst the current cadre of business managers; and for the longer term
    - ensuring a flow of prospective future managers capable of bridging between science/technology and business.

54. This study should include an assessment of the various existing initiatives where the Scottish Government and Scottish Enterprise seek to build R&D management capabilities. POC, SMART and SPUR grants now incorporate external project management support. Scottish Enterprise has a national “Product Development Improvement Programme”. SE Lanarkshire had an initiative to develop innovation management skills in executives from its high growth company portfolio, many of

26 GlobalScot: https://www.globalscot.com

which were traditional and family-run businesses. SE Lanarkshire also ran overseas management development missions, providing access to executives in world-leading innovative organisations. A related step should probably be an assessment of any R&D/innovation management programmes at the Scottish business schools and of lessons to be learned from business schools further afield: for example Cranfield University offers a wide range of courses in this area enabling practical skills development from short but focused courses.

Tools

55. In Recommendation 7 we raised issues around management capabilities. One factor in proceeding with business investment in R&D concerns having confidence in internal capabilities to ensure quality of the R&D. In the same way as businesses in Scotland can access tools for developing business plans, marketing strategies etc., tools to assist in ensuring the quality of any R&D undertaken by or for the firm would be useful to have in the business toolbox. The delivery of the tool would contribute further to the overall awareness raising and promotion of business R&D.

Recommendation 8: Tools for businesses investing in R&D.

56. Scottish Enterprise should consider introducing a "national product" concerned with the management and quality assurance of business R&D. Our exploratory research indicates that the R&D Effectiveness Index may provide a suitable basis for the development of a tool, specifically for smaller companies[27].

The Service Sector

57. The Scottish Government reported that the service sector was largely responsible for the overall growth in Scottish GDP over the year to the end of 2007, where the service sector grew by 3.4% while the Scottish economy grew by 2.2%[28]. Furthermore, within the service sector, banking showed the largest annual growth (9.3%)[29].

27 McGrath M.E.; Romeri M.N. Journal of Product Innovation Management, Volume 11, Number 3, June 1994, pp. 213-220(8)

28 High Level Summary of Statistics, Scottish Government, 2008 http://www.scotland.gov.uk/Topics/Statistics/About/HighLevelTrends

29 http://www.scotland.gov.uk/Topics/Statistics/Browse/Economy/GDP/Findings

58. Scottish Financial Enterprise (SFE), the representative body for the financial services sector in Scotland, indicates that the industry accounts for £7bn (over 7%) of Scotland's GDP. In the five years (2000-2007), financial services in Scotland grew by 60% (47% in the UK) while the overall Scottish economy grew by 14%. The financial services industry accounts for one in ten Scottish jobs, with over 108,000 people directly employed in the industry and over 100,000 more employed in support services. *In the six years to 2004, direct employment in financial services in Scotland rose by 31.5% compared with 7.5% for the economy as a whole.*

59. In the context of an analysis of R&D performance, this raises two issues. It is argued that the structure of the Scottish industry-base, having a large, low research-intensity service sector, by itself biases the national performance with respect to BERD: and that the importance of the banking sector in particular adds to this "problem". The definitions used in the presentation of statistics therefore present Scotland's innovation performance as poor with respect to comparator areas.

60. Examination of BERD in Scotland by sector, however, indicates that just as performance across the board lags behind UK and OECD norms, the services sector in Scotland appears to perform at a relatively low level of R&D investment – the BERD in Scotland 2003 Report reports an R&D expenditure per employee in the services sector in Scotland of £125, compared to a UK figure of £417, a UK : Scotland ratio of 2.4. The same ratio for manufacturing is 1.8 and for all business sectors 2.2.

61. Yet R&D and its link to innovation is very important to the financial services sector as evidenced by, for example, the development of the ATM by NCR in Dundee and more recently the Clydesdale and Yorkshire Banks with their 'speaking' ATM allowing use by dyslexic and sight-impaired customers. This service was developed in partnership with NCR, another example of an international technology supply company which has been committed to the Scottish market through its major facility in Dundee.

62. Unfortunately, when technology is embedded in equipment purchased from vendors (embodied R&D), this does not show up in, for example, financial services R&D data metrics but rather under the sector headings appropriate to the vendors. Further work is required therefore to clarify the significance of the service sector's innovation supply chain and how this might be reflected in the BERD data. This would require detailed consultations with a range of institutions to examine their new product/

service development processes to determine if there are areas where the Scottish market (including the science base) might serve them to a greater degree.

63. Contracted-out research also leads to under-reporting of for example banking R&D. Retail banks see themselves competing for customers through quality of service. They do, therefore, constantly seek to innovate their service offering. An example of this is the development of e-banking systems by the University of Edinburgh School of Engineering and Electronics for Lloyds TSB. This is contracted through their Bristol office and involves the use of dialogue engineering such as speech recognition and synthesis, and conducting usability testing on the public of these e-banking development and call centre systems in the UK as well as the Far East. These are major development contracts with total funding exceeding £8m as the financial institutions are increasingly concentrating on delivering an innovative customer experience – one that is targeted to unique market segments which emphasise convenience, service and value.

64. Another example of external contracted development is the new contactless payment card which has just been launched by RBS in partnership with Mastercard. This card can be used as a normal debit card, but additionally can make contactless payments of up to £10 to buy small items like coffee or meals, avoiding the need for the customer to carry around small amounts of cash. RBS have been trialling the use of the card through Starbucks outlets in Edinburgh. Here the technological innovation is embedded within the cards produced by Mastercard. However, the innovation in terms of customer service offer has been developed by RBS. A tribute to the importance of this innovation has been paid by Brian Triplett of Mastercard's rival Visa: *"The contactless infrastructure lays the foundation for a lot of new innovation over the next few years"*[30].

65. International investment banking organisations rely heavily on CPU-hungry(central processing unit) IT platforms hence they do invest in R&D in grid computing, mathematical modelling for derivatives trading etc. and network traffic analysis. Unfortunately, these R&D activities are not procured within Scotland.

66. As the examples above show, there is a reasonable level of financial services R&D interaction taking place between the technology vendors in Scotland and the

30 http://news.bbc.co.uk/1/hi/programmes/moneybox/5136574.stm

university sector but because BERD measures in-house R&D only, much of this activity is not captured.

67. Whilst improvements in retail banking services may be large-kit technology driven, the more intangible improvements in risk management, for instance, require collaboration across a range of academic disciplines (mathematics, computing, cognitive science). This is the area where there could, with benefit, be a more joined-up approach both within the research base and with the markets such as financial services. The internationally-competitive research excellence in electronics and informatics within Scotland would appear to possess the necessary capacity and capabilities to deliver significant added value to the industry.

68. It is evident that Scotland's retail banking sector excels in an internationally competitive market and is highly innovative. It must continue to be highly innovative to remain at the forefront internationally. It is not, however, R&D intensive in a traditional Frascati definition of the term R&D. It clearly has interests in the outputs from R&D in its supply chain and purchases products which embed prior R&D. Furthermore, from our research on the sector internationally and consultations with senior representatives of Scotland headquartered banks, the Scottish research base has particular centres of excellence that should be of strategic interest to the retail banking sector.

Recommendation 9: Engage with the Financial Services Sector.

69. The research-intensive Scottish universities along with the Scottish Funding Council, given the latter's interests in knowledge transfer, should engage proactively with the global banking sector headquartered in Scotland and elsewhere to assess areas of mutual value that can be exploited through research collaborations. It seems intuitively obvious that, given the prominence of the banking sector in the Scottish economy, the work of the Scottish university sector, in research and knowledge transfer, should be seen to relate and be responsive to the sector's needs and opportunities.

Recommendation 10: Achieve a better understanding of R&D and innovation in the Service Sector.

70. We believe that there would be merit in a closer examination of the R&D (and innovation) performance of the services sector in Scotland in order to fully understand and respond to the evidence of seemingly low investment in BERD. There would be value in analysing the bias introduced to these headline figures by

the knowledge-intensive banking sector (and other financial services) in order to examine and better understand, the determinants of R&D investment patterns in other service sub-sectors.

Forum for Debate and Consensus Building

71. This study by the SSAC has been conducted at a time when the Scottish Government, Scottish Enterprise and the Scottish Funding Council (through its Knowledge Transfer and Innovation Group) are all engaging in policy related research relevant to R&D and innovation in Scotland. We believe that a wider debate is needed to make the case for greater investment in industrial R&D and to align the interests of all the stakeholders. Just as the Royal Society of Edinburgh was instrumental in encouraging the commercialisation of academic research, so we believe it to be the most appropriate impartial body to take forward the debate.

Recommendation 11: A Public Forum for Dissemination and Consensus Building.

72. It is proposed that a national conference is convened to disseminate the various pieces of recent and current complementary research that is of of national significance in terms of taking this agenda forward in a consensual manner. We suggest that the Royal Society of Edinburgh (RSE) consider acting as the catalyst and organiser of such a forum.

73. The RSE is actively considering this recommendation and is constructing a proposal for a National Forum for Business R&D, which will identify and stimulate processes that will increase business R&D investment and to suggest how appropriate strategies might be developed in Scotland.

Concluding Remarks

74. Publication of this report coincides with the most difficult economic conditions in recent history. Now is the time to invest to improve the competitiveness of the Scottish business sector in preparation for the end of the present recession. SSAC believes that a strong industrial R&D base is an essential component to competitiveness, contributing to innovation and hence economic growth and providing the link with a well-funded academic research base. Action is needed by the Scottish Government and its agencies. Where Scotland's relatively weak expenditure on industrial R&D is a matter of poor data or measurement, we should correct our methodology. Where incentives are needed to increase research capacity, we should invest in them. Where research management skills and expertise are deficient, we should put appropriate training in place. Significant changes, both cultural and financial, have taken place within our Universities that encourage engagement with business to take up new knowledge and technologies. Without an improvement in Scotland's industrial absorptive capacity, the potential for enhancing our economic competitiveness through research-led innovation will not be realised. We propose that the recommendations made in this report will contribute to that enhancement.

Appendix 1

Workshop

1. The SSAC held a workshop at the RSE on 28 November 2005 with the objective of exploring:
   - How university-industry interactions might be improved in Scotland;
   - How government support and incentives for R&D might be better focused to the benefit of the industrial base in Scotland; and
   - How the science base could assist Scottish industry to grow its overall value thereby leading to enhanced economic development in Scotland.
2. Speakers included:
   - Simon Best, Chairman, Ardana
   - Professor John Roulston, CEO, Filtronic
   - Dr James Anderson, formerly NCR
   - Dr Richard Yemm, CEO Ocean Power Delivery
   - Mr Chris Warkup, CEO Genesis Faraday
   - Mr Ian Howie, Scottish Government
   - Ms Margaret McGarry, Scottish Enterprise
3. Presentations were interspersed with discussion sessions involving members of the audience.
4. Approximately 100 people attended from industry, academia and government bodies.

Conclusions and Findings

General

5. Some companies are trying very hard to do R&D in Scotland – we don't give enough credit/publicity to those who do.

6. Jim Adamson showed what companies have to do to get out of the product development rat race and into long term R&D to secure the future of their companies. A fundamental question is – what would it take to get more companies to mimic NCR's success in R&D?

7. The service sector dominates and it is increasingly acknowledged that they are highly innovative but do not necessarily carry out their own R&D, or have their own R&D recognised.

People factors

8. Supply side issues were discussed, but we need to understand better whether school pupils are responding to perceived changes in demand or are simply not attracted to relevant subjects. The recent rise and fall of computer science undergraduate numbers could have been stimulated by market forces rather than personal interest.

9. Scotland lacks people with advanced management skills, advanced manufacturing skills, people with the ability to generate change, and those without fear of failure. Networks are important to attract and support such people, but there is little critical mass in most sectors outside the service industry?

10. Business schools surely have a role to play here in educating the next generation of managers – but are the Scottish business schools good enough?

Funding

11. Access to venture capital. Messages were mixed on this – some speakers believed that VC funding is readily available to good propositions. There is also a raft of follow-on funding mechanisms in Scotland.

12. Funding gaps remain between Research Council grants to the academic sector and industry. Intermediate funding and intermediate bodies may play a role here. ITIs are injecting funding for applied research and development into industrial/academic collaborations.

13. The SBRI model may have considerable merit particularly in Scotland where the SME sector is important. Although this is now mandated by the Treasury, its impact/availability in Scotland is questionable.

14. Incentives for applied academic research are poor. The RAE conspires against this despite attempts to encourage better recognition of applied outputs. A rebalancing of core funding between research-driven and knowledge-transfer-driven streams is highly likely to be effective.

15. Timescales for taking basic research ideas to market are long, and not adequately funded once basic research is deemed complete.

16. There are perhaps too many funding schemes. Less complexity would be helpful.

17. Government has an important role to play in procurement.

Valuing Research and Development in Industry

18. Demise of major intermediate innovators, eg RSRE/DRA – the Public Sector Research Establishments – which stimulated high technology industries (especially electronics systems). Now we are trying to replace them with (arguably inferior) substitutes – Faradays, Kelvin Institute, some of the models Margaret McGarry described.

19. Need to get industry to divert its attention from day-to-day problems and invest in the future (Jim Adamson's skunk works).

20. Multinational control of Scottish industry has stultified innovation (with some exceptions, NCR and HP). Local R&D opportunities/efforts not given credibility by corporate HQs.

21. We need better ways of valuing good ideas and R&D investment. Short tem accounting models don't achieve this. (Capitalising R&D)

22. FEC attempts to overvalue University IP/knowhow and hence gets in the way of knowledge transfer.

Appendix 2

Consultant's Brief

1. How important is research and development to key industrial sectors and how vital are "R" and "D" to some sectors? For example, does the service sector need R&D in its long-term product focused sense, other than through the more traditional technology-focused sectors?

    - Senior members of the banking/financial services sector, for example, have suggested that R&D is irrelevant to them. Is this simply because they do not recognise the type of research/development that they do undertake either directly or through third parties is simply not considered to be traditional R&D?

2. What constraints apply to the growth of industrial R&D in Scotland. To what extent do policy frameworks, regulatory conditions, etc. play a role?

    - People factors appear to be very important. There is no shortage of graduate and postdoctoral talent, but the low availability of good managers at project level, and risk-taking leaders at company level, appears to be a constraint to the growth of business R&D on the one hand, and the growth of companies to the size needed to support R&D activities on the other. How strong is the evidence for this?

3. Is industrial R&D in Scotland given sufficient recognition and support?

    - Is it properly identified and measured? For example, is R&D in the service sector, which dominates Scottish industry, recognised as such? Do classification schemes require amendment in an industry which is increasingly knowledge-based?

    - Is industrial R&D given adequate funding support from government? Are SMART/SPUR awards, R&D tax credits, etc. sufficiently attractive to encourage companies to conduct longer-term research and development? Are they effective at encouraging companies out of short-term product improvement cycles into longer term research?

    - What is the role of government procurement in encouraging innovation and underlying R&D?

- Has the demise of the public sector research establishment had a significant impact on the volume of industrially-focused R&D, and are replacement mechanisms effective? Such organisations appear to have been major providers of what is now fashionably called 'translational' research. To what extent is/was this true?
- The SBRI scheme appears to have been very successful in the USA, has been mandated by the UK Treasury in the 2005 budget, but appears to have been patchily implemented. Its introduction in Scotland is questionable.

4. Is Scotland a competitive location for industrial R&D?
   - The growth of low cost countries with highly qualified workforces and substantial government subsidy appears to represent a substantial competition to Scotland as a location for R&D.
   - Other mature economies, apparently subject to the same WTO standards as ourselves, seem to be able to provide 100% funding for industrial R&D. In the UK, government support is significantly smaller and requires matched funding from industry.
   - The introduction of full economic costing in the HEI sector is seen as a deterrent to industrially sponsored research and may drive more of it abroad. Can this impression be substantiated at the current time?
   - What role does/could government play in attracting significant inward R&D investment to Scotland?
5. Do effective and authoritative mechanisms exist for measuring the quality of industrial R&D? If so, how well does Scotland perform on such measures?

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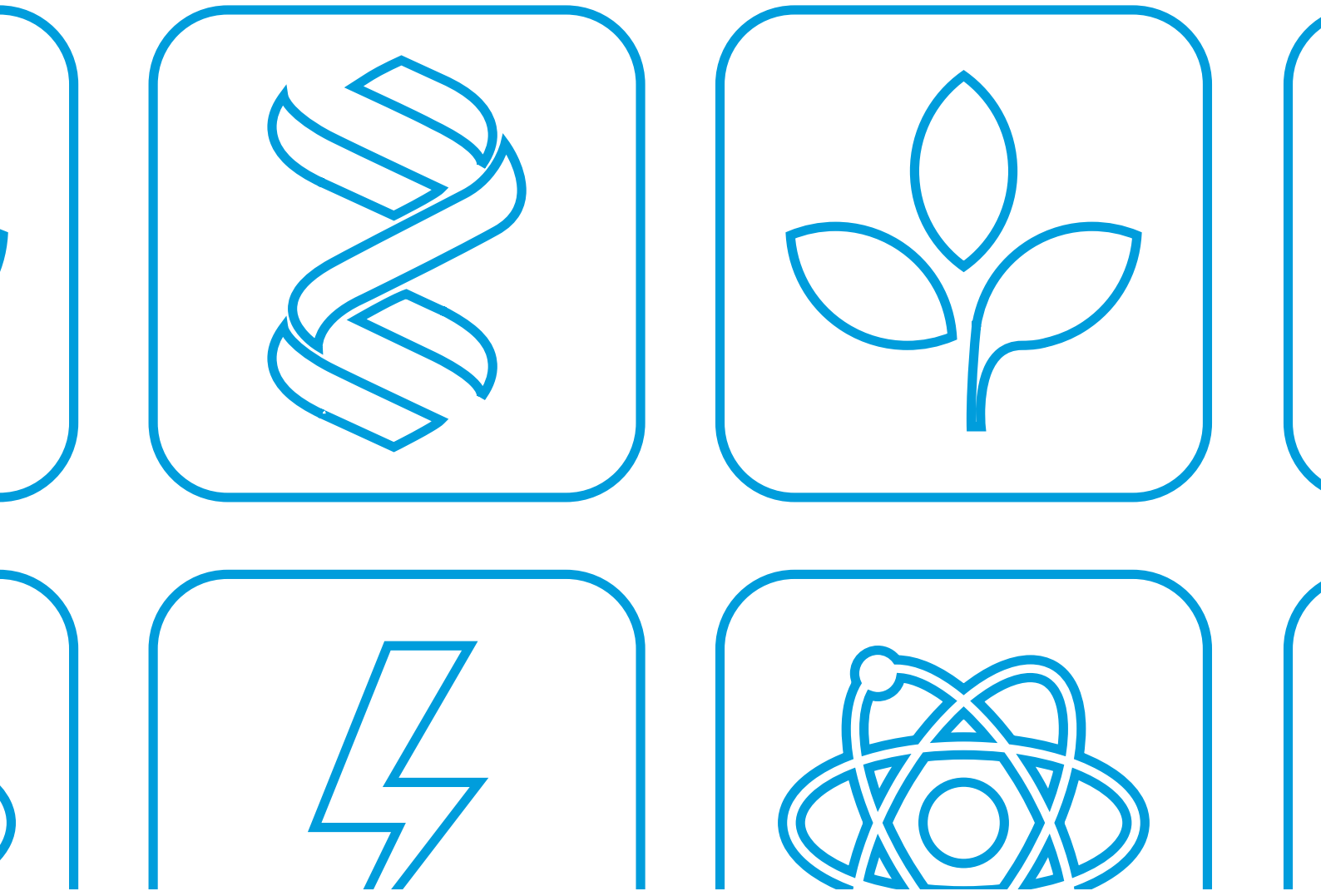

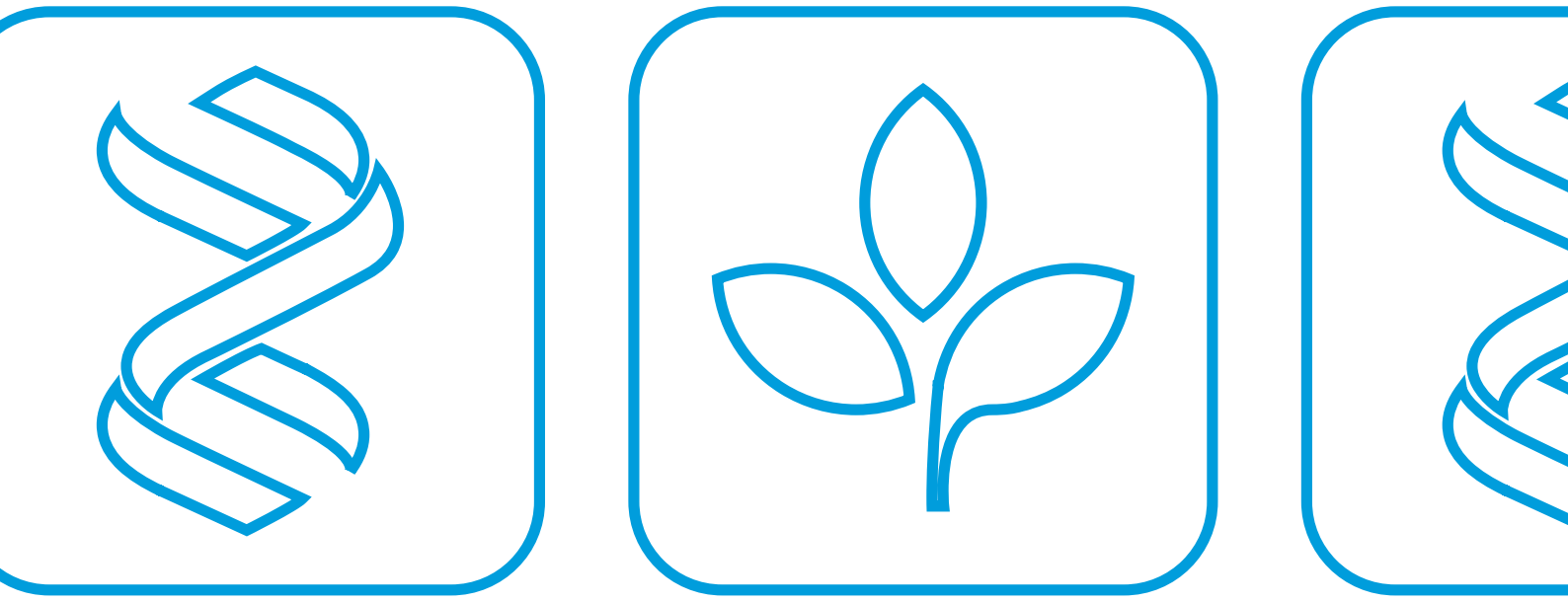

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