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NESTA Policy & Research Unit

Science and Innovation Strategy for Scotland: NESTA Response to Consultation

Scotland has the opportunity to develop a broad-based innovation policy that recognises and builds upon its unique strengths, and focuses on the outcomes from innovation that reflect its national priorities.

Introduction

Why is NESTA responding and who does it represent?

NESTA (the National Endowment for Science, Technology and the Arts) is the leading agent for transforming innovation in the UK. We are the largest single endowment in the UK devoted exclusively to innovation.

We invest in early stage companies, inform innovation policy and encourage a culture of entrepreneurship. Our aim is to transform the UK's capacity for innovation. We are the only UK body that actively works across sectors, bringing together science, technology and the arts.

Respondent Information

Address: NESTA
Policy & Research Unit
1 Plough Place
London EC4A 1DE

Phone: +44 (0)20 7438 2500

Type of Institution: Non-Departmental Public Body (NDPB)

General Comments

Innovation is more than science and technology

Science is the dominant theme of the strategy, with innovation seen as a subcomponent of this. There are elements within the document which give mention to the "wide spectrum" of innovation activity, and we applaud this recognition. However, this broader view is not reflected in the consultation's detailed aspirations or action points, which primarily interpret innovation as a science-related activity. As such, the document is a "Science in Innovation" strategy, rather than an innovation strategy.

In the current document, innovation is restricted to activity that leads to a new product or service, rather than a broader exploitation of new ideas. This approach does not recognise the economic and social potential of other forms of innovation, including identifying and exploiting new markets, developing new business processes, new organisational structures, and new methods of collaboration. For example, easyJet's innovation was not their business model – this was borrowed from Southwest Airlines in the United States – but rather their exploitation of the model into new markets. easyJet now generates over 1.3B in annual revenue and employs over 4000 people. Similarly, the iPod was an assembly of relatively "old" technologies in a "new" form, but much of the success derives from its user interface and from its integration with the iTunes system, which is essentially a business process and marketing innovation.

The example of financial services in Scotland further illustrates the importance of non-scientific innovation. The sector has experienced strong growth and has become central to Scotland's development. Financial services generates £7 billion (7%) of Scottish GDP (measured as Gross Value Added), and accounts for 10% of Scottish jobs, employing over 113,000 people directly and over 100,000 more in support services. In the last five years (2000 to 2005) financial services in Scotland grew by 36% while the overall Scottish economy grew by 9% and the whole of the UK financial services industry grew by 15%.¹ Yet these sectors do not have a particularly significant grounding in the nation's science base. Rather, innovation has been driven more by new business models, service offerings, and markets.

Recognising Scotland's broad innovation ecosystem

This limited scope may have strong implications for Scotland's Science and Innovation Strategy. The Scottish innovation system comprises a complex set of actors and relationships, including businesses, their suppliers and customers, universities and research institutions, policy-makers, institutions to facilitate technology diffusion and transfer, investors². All of these can exist at the local, Scottish, UK and international levels. Thus, the innovation system encompasses not just idea generation, but the active exploitation and commercialisation of those ideas.

Scotland has a number of initiatives which explore and support various elements of this system. The proof of Concept fund and the Scottish Enterprise / Royal Society of Edinburgh Enterprise Fellowships are impressive schemes to stimulate commercialisation of ideas. Scotland's three Intermediary Technology Institutes (ITIs) are another novel approach to identifying and supporting innovation in strategically important areas, tying together research activities with market opportunities and business needs.

¹ Scottish Financial Enterprise. "Overview of Scotland's Financial Services Industry". http://www.financescotland.com/info/overview_scottish_financial_industry. Cited 5 January 2007.

² S. Roper, J. Love, P. Cooke and N. Clifton. "The Scottish Innovation System: Actors, Roles and Actions." January 2006 (Cardiff University).

However, the consultation document primarily focuses on the supply-side nature of innovation (i.e. research and development, university-based research, science education, etc.). The demand-side of the innovation equation is missed. This is exemplified in the depiction of the science and innovation base, which omits users and any other form of a broader innovation community (individuals or networks). It also thereby excludes imaginative interventions to stimulate demand, such as prizes, managed challenges and procurement.

The government has a strong role to play in stimulating demand for innovation

For example, looking at Figure 1 [A Science and Innovation Nation], the government is included only as a funder of science, and not within the science and innovation base (with the exception of the NHS). This ignores the many other roles that the government may play in an innovation ecosystem, both as a source of innovation itself (particularly in the design of public services), as well as a catalyst for innovation elsewhere – through, for instance, environmental regulation. Recent reports by the European Commission have placed a high priority on the importance of 'lead markets' in stimulating innovation, describing several of the mechanisms available to the government in stimulating such markets. These include regulatory activity, standard setting, procurement, and proactive tax policy.³

Theme 1: Maintaining and Developing the Excellence of the Science Research Base

A science base is only one component of Scotland's innovation ecosystem

Throughout the consultation paper, the document consistently reiterates Scotland's ambition to become a "science nation." Undoubtedly, increased public investment in science and technology has been necessary and valuable. Through such investment, Scotland has developed considerable science strengths in its universities and research institutes, particularly in strategic areas such as energy and the life sciences. Over 80 million has been spent since 1999 on commercialisation and knowledge transfer activities alone.⁴

However, this approach has historically led to an innovation policy being virtually synonymous with science policy – in execution, if not in rhetoric.⁵ This is somewhat understandable given the history of innovation policy. First, innovation policy grew out of science and technology policy, but has subsequently absorbed aspects of enterprise policy, and education and skills policy as well. However, this process of absorption has allowed science and technology to remain dominant in innovation policy. In other words, areas such as education and skills have been grafted onto a framework for innovation policy that remains focused on SET, rather than causing this framework to be radically revised.

³ European Commission, "Creating an Innovative Europe". Aho Group Report. January 2006.

European Commission, "Putting knowledge into practice: A broad-based innovation strategy for the EU". September 2006.

⁴ Scottish Executive. "Science Policy and Funding." <http://www.scotland.gov.uk/Topics/Business-Industry/science/16607/21286>. Cited 25 December 2006.

⁵ NESTA. "The Innovation Gap". November 2006.

Scotland's innovation strategy should encompass its full range of innovation activity

NESTA's recent research report, *The Innovation Gap*, challenges the traditional perception of the innovative performance of the UK nations and explains how policy needs to change to reflect this revised view. The report argues that the UK is actually more innovative than traditional indicators show, and that innovation policy needs to develop from a focus on science and technology to support the full range of innovation in the UK.

A heavy emphasis on a science base, both in innovation policy and in its traditional measures, are based on a 'pipeline' view of innovation that does not reflect how innovation happens in the vast majority of the UK economy. Supply-side indicators such as expenditures on research and development have largely driven many policy interventions, even though they fail to capture the true innovative activity in sectors such as financial services, retail, consultancy and the public sector. Together, these account for around 94% of the UK economy. Even in the sectors that the traditional indicators do represent, they fail to accurately reflect the level of innovative activity.

High-tech sectors, while important, represent only a small percentage of even the 'leading' innovative economies in Europe. The efforts so far in Scotland to increase the commercialisation of university research, boost interaction between industry and the science base, and to support cutting-edge R&D in businesses, are therefore necessary but not sufficient.

Scotland needs an innovation strategy tailor-made to its specific context

A striking feature of most innovation policies around the world is their similarity. Almost without exception, they focus on key sectors such as IT, biotech and nanotech; on increasing public and private investment in R&D; and on strengthening links between the science base and industry.

Accordingly, NESTA strongly agrees with the consultation paper's ambition that Scotland continues to develop its "ability to identify new areas of scientific opportunity or strategic importance to Scotland's economy and society". Scotland must create an innovation strategy that is appropriate to its particular strengths and challenges. A modern Scottish innovation strategy will seek greater clarity regarding the *outcomes* of innovation (rather than just the outputs), determined by what Scotland as a nation wants from innovation, rather than focusing on innovation as an end in itself.

Theme 2: Enhancing international connections and capturing overseas investment

Exploiting non-scientific knowledge flows

NESTA appreciates that the consultation has included international connections as one of its key themes. However, within the consultation document, these connections and overseas investment are referred to only in terms of science and research (i.e. attracting capital for research and top international researchers).

As noted earlier, many of the innovations with the most commercial or social promise may not originate from the traditional science base, but from other elements of the economic system. As an example, initial applications of social networking – itself an innovation rooted in the idea of collaborative activity – did not originate within a science lab.

Tapping into global pipelines of innovation and collaboration

Recent research by the Cambridge-MIT Institute has shown that linkages into national and international networks can be more important to business

innovation than local collaboration, particularly for manufactured and service products.⁶ Such networks involve multiple actors within the innovation ecosystem, including investors, suppliers, distributors, and customers, any of which may be the source of high-potential ideas. Customers, in particular, have valuable knowledge of local markets and their particular needs.

Scotland's innovation strategy should encourage linkages not just with the international science base, but with these other actors as well. Such networks enhance Scotland's capacity to integrate (adopt and use) knowledge, rather than to generate it (or be the first to commercialise it), that we should be most concerned.

Theme 3: Intensifying knowledge exchange between academia and business

Scotland should be wary of traditional metrics for commercialising university research

As with innovation strategies elsewhere in the UK and Europe, the consultation document maintains an emphasis on knowledge transfer between universities and industry. The document is consistent with the findings of the Lambert Review, which also identified that businesses (particularly SMEs) are making insufficient use of the university knowledge base.

Contributing to local and national economic and social growth forms an important third mission for universities, augmenting the traditional objectives of research and education. However, we would caution that Scotland be wary in developing specific targets for commercialisation of university research as the major means of such contribution. Within the United States, a mere 10 institutions account for a third of U.S. university-issued patents and half of university licensing income.⁷

Spin-out activity, in particular, is only a partial measure of the success of science policy. As one of the UK's largest investors in early-stage companies, NESTA has extensive experience working with university spin-out companies. In general, the strengths of universities are not in providing the management talent and funding required for successful start-up activity, particularly at the crucial proof-of-concept phase. Specifically, Scotland's Science and Innovation Strategy should consider the different skills required by a licensing strategy as opposed to a spin-out strategy and plan accordingly.

Although their long-term impacts remain to be seen, novel arrangements to exploit university research such as those employed by the IP Group and Angle Technology should be investigated and considered.

Universities as producers of talent and not just technology

Measures of patent activity, license revenue, and spin-off success do not effectively capture the full economic contribution of universities. Other spillover benefits include the attraction and retention of top faculty and students, including market-based drivers in the research agenda, providing a route into global knowledge flows and strengthening the local innovation ecosystem.

Research by the Science and Technology Policy Research Unit (SPRU) at the University of Sussex has shown that the primary contribution universities make to the economy is not their generation of new ideas, but their generation of

⁶ M. Abreu, V. Grinevich, M. Kitson and M. Savona. "Absorptive Capacity and Regional Patterns of Innovation". Presentation to the DTI Innovation Economics Conference on 1 December 2006.

⁷ R. DeVol et al. "Mind to Market: A Global Analysis of University Biotechnology Transfer and Commercialization". Milken Institute. September 2006

graduates skilled in exploiting ideas. University-industry interaction can support this objective by providing a practical context for student research and study. However, all educational institutions have a responsibility for including the development of skills for innovation throughout their curricula. This is discussed further in our response to Theme 5, on page 7.

Theme 4: Expanding business innovation

Innovation in business is more than R&D

In the consultation document's introduction to Theme 4, it notes that business innovation must cover "a wide spectrum of activity, from at one end, innovation building on scientific advances, through to, at the other end, less science-based activity such as adoption of new business processes and new design." However, in the body of the section, it discusses innovation – and provides related targets – solely from an R&D perspective.

Traditional definition of R&D is not appropriate for the breadth of innovation occurring in Scotland

High-tech sectors, where R&D is most relevant, represent only a small percentage of even the 'leading' innovative economies in Europe. Thus, while it is the case that per capita expenditure on R&D in the UK nations lags behind that in other leading European nations, this ignores the different composition of the UK's economy, particularly our large service sector where formal research and development is far less important than other forms of investment in innovation.

There are also technical reasons why the UK's innovative performance is downplayed in such analyses. For example, the internationally-agreed definition of R&D excludes development activities such as petroleum exploration even though these generate innovations and new scientific discoveries. This example is of course particularly pertinent to the UK with its large oil exploration sector. This sector spends on average £1.11 billion per year in the United Kingdom Continental Shelf (UKCS) area alone on activities that could be interpreted as the sector-specific equivalent of R&D. Including this expenditure alone as R&D would increase the would likely have a significant increase in Scotland's business R&D intensity.

According to the 3rd Community Innovation Survey (CIS3), Scotland has a significantly higher proportion of firms that are novel innovators – firms which have introduced a new product or process not only to their organisation, but to the market. This impressive performance has occurred despite a lower average expenditure on R&D per employee than that the UK.⁸

Any targets for R&D need to be sensitive to context, achievable, and meaningful

As a result of the problems with traditional indicators, there should be a greater clarity regarding public interventions in support of private R&D, in particular in the area of target-setting. Interventions such as tax credits for R&D can have a number of motivations, from encouraging the development of new products and processes, enhancing the competitive advantage of domestic businesses against foreign competition, to helping the development of emerging high-tech industrial sectors.

Given multiple objectives such as these, it is a complex matter as to what the optimal level of R&D spending might be across a national economy. Hence any targets for increased R&D spending need to be based on thorough analysis of the actual need for such spending, perhaps on a sectoral basis as it is relevant to the Scottish economy, rather than a simple 'more is better' approach.

⁸ J. Michie, C. Oughton and M. Frenz. "The Community Innovation Survey: An Analysis for Scotland." A Report for the Scottish Executive.

Furthermore, Scotland requires further investigation into other barriers to business innovation. For example, CIS3 research found that Scottish firms have lower levels of organizational innovation, such as advanced management techniques, than in the UK. Organisational design and practices can have a significant influence on a firm's ability to identify and exploit ideas for growth, and therefore should also form a component of a holistic Scottish innovation strategy.

A modern innovation strategy will promote innovation as appropriate to each sector of the economy

Scotland needs a textured innovation policy that recognises that one size does not fit all sectors. Good innovation policy is based upon a deep understanding of the dynamics driving innovation in areas such as the financial services, clean energy production and distribution, popular music and construction. In particular, we must identify those sectors where innovation may be lacking, and develop targeted policy interventions to suit.

Theme 5: Modernising science education and promoting science careers

Science education provides a foundation for innovative capabilities...

The typical focus for policy and debate regarding education and innovation concerns the supply of people with highly advanced science, engineering and technology (SET) skills. This reflects the traditional view equating the generation of new knowledge through fundamental scientific research. This perspective has been highlighted by the recent press coverage regarding the closure of a few chemistry departments, or the massive numbers of science graduates being produced by China and India.

NESTA agrees with the consultation document that education and training will play an important role in developing Scotland's innovative capacity and performance, including the ability of the Scottish education system to generate a flow of highly able SET graduates. Clearly, SET education provides a foundation for a range of innovation-rich sectors such as engineering and technology.

Having large numbers of SET graduates helps to raise the UK's capacity to absorb knowledge created elsewhere (and lowers the cost of doing so). Given sufficient SET graduates working domestically in related fields, foreign R&D can be as valuable to the Scotland as domestic R&D.⁹ The Roberts Review 2002 noted that "Scotland's proportion of the UK's science and engineering graduates is higher than its proportion of UK R&D employment (in part because of its high participation rate in higher education)", and that "the supply of SET skills in Scotland was more buoyant than elsewhere in the UK." This suggests that the supply and demand issue is not as urgent in Scotland as in the rest of the UK, although this is not an argument for complacency.

NESTA agrees that science should be promoted to young people as a rewarding career path. Our experience in this area shows that a range of approaches is needed, depending on the target audience. These include identifying and promoting positive role models, providing authentic work experiences where young people can work on genuine products, providing higher quality information sources for careers advisors, and using the media and popular culture to influence young people and those that influence them, particularly parents.

⁹ Jaumotte, F., and Pain, N. (2005), From Ideas to Development: The Determinants of R&D and Patenting, OECD Economics Department Working Paper No. 457, (OECD, Paris).

...which are highly prized throughout the economy, and not just in science

However, many SET graduates do not work in direct SET areas. Only two per cent of SET graduates are employed in R&D services.¹⁰ Forty-five per cent of SET graduates work in non-SET occupations, including jobs in banking, finance and insurance.¹¹

This does not mean that they are not contributing to the UK's innovative capacity. Indeed, although the importance of pure university-based research in innovation has been over-estimated, the role of universities in enabling innovation by providing trained people who are skilled at solving complex problems has traditionally been under-valued. Indeed, for SET graduates it is these more abstract products of their science education – hypothesising, problem-solving, critical analysis, etc. – that are particularly valued by employers, frequently more so than any particular science or technological knowledge¹². These are skills critical to innovation in any sector, be it science, the creative industries, or social enterprise.

Science education must be real and practical...

As noted in NESTA's 2005 report *Real Science*, high quality science education needs to involve frequent and authentic science experiences. These give students the opportunity to conduct practical experiments, engage with real materials and equipment, tackle their own questions and hypotheses, and investigate the genuinely unknown. Such experiences are critical, particularly for young people, to generate the spirit of enquiry which is part and parcel of innovative behaviour.

Modernising science education to meet this demand will require a range of policymakers and influencers of education working together to remove barriers to authentic science experiences, including insufficient time among teachers and a lack of confidence in the value of such activities among some school leaders.

Scotland's Science Centres policy demonstrates aspects of this, encouraging schools and teachers to use new resources such as the Scottish Schools Equipment Research Centre.

...but it is not the only way to develop the skills for innovation

Scotland's innovation strategy must recognise that developing the knowledge and skills required to innovate and to absorb innovation are not the sole remit of the science curriculum. They need to be widely distributed in society, rather than being centralised in R&D departments or elite academic institutions. The OECD has suggested that the most significant inhibitor of UK 'innovation' (understood as the diffusion of productivity-enhancing technology produced elsewhere) is an insufficient capacity to absorb knowledge created elsewhere.¹³

Addressing this issue requires an education system that is able to develop foundation skills – analysis, problem-solving, creativity, imagination, resourcefulness and flexibility – across all subjects within the curriculum. In other words, we must enhance our collective capacity to initiate, absorb, support, organise, manage, and exploit innovation in its many forms. It is with our capacity to integrate (adopt and use) knowledge, rather than to generate it (or be the first to commercialise it), that we should be most concerned. This applies as much to, if not more so, ideas generated outside Scotland and the UK as it does to ideas generated domestically.

¹⁰ Department of Trade and Industry (2006), *Science, Engineering and Technology Skills in the UK*, DTI Economics Paper No. 16, (DTI, London).

¹¹ Ibid.

¹² NESTA. "The Innovation Gap". November 2006.

¹³ Ibid.

The principles underlying Scotland's Curriculum for Excellence and programmes of work such as Determined to Succeed provide the basis for developing these skills. Scotland's Enterprise in Education policies are also quite advanced in relation to most of the UK, and can provide a useful foundation for the inclusion of skills for innovation.

Intermediate skills are also vital to the UK's capacity for innovation

As has been suggested by the Leitch Review, the UK's future prosperity will also depend upon its wider skills base; the UK workforce must have the skills to take advantage of technological developments, and to cope flexibly with the changes brought by globalisation.¹⁴ Workers with more skills are demonstrably more productive and also more flexible and adaptable. A recent study indicates that increasing the literacy score of a country by one per cent leads to a 2.5 per cent rise in labour productivity and a 1.5 per cent increase in GDP per head.¹⁵

By measures of intermediate skills, Scotland performs well against the UK average, with 72 per cent qualified at Level 2 or higher, in comparison to the UK's 64 per cent.¹⁶ Nonetheless, compared to some of its competitors, there remains room for improvement – eighty-five per cent of German adults and 77 per cent of French adults of working age are qualified at Level 2 or higher.¹⁷

This level of achievement must continue to be challenged, since low intermediate skills undermine our national capacity to absorb and exploit innovation.

Conclusion

Scotland should build on its innovation policy heritage and seize this opportunity to develop a world-leading strategy for innovation

Most national approaches to innovation are remarkably similar in their focus on advanced scientific and technological invention. Scotland now has the opportunity to develop a broad-based innovation policy that recognises and builds upon its unique strengths, and focuses on the outcomes from innovation that reflect its national priorities. We believe that the scope implied by the consultation document is not ambitious enough in this regard.

¹⁴ HM Treasury. Leitch Review of Skills, Skills in the UK: The Long-Term Challenge, Interim Report, Chapters 1-6. 2005.

¹⁵ Coulombe, S., Tremblay, J., and Marchand, S. International Adult Literacy Survey Literacy Scores, Human Capital and Growth Across Fourteen OECD Countries. 2004.

¹⁶ HM Treasury. "Prosperity for all in the global economy - world class skills, final report". 2006.

¹⁷ Ibid. 'Level 2' qualifications include five or more GCSEs, O-Levels or equivalent at grades A*-C, NVQ Level 2, and BTEC first or general diplomas.