The Scottish Innovation System: Actors, Roles and Actions

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Executive Summary

Introductory Remarks
This report provides a ‘rough guide’ to the Scottish Innovation System (SIS). A key focus is the identification of the main actors, their roles in the system, and the level of system interaction. An evaluation of system strengths and weaknesses is provided at the end of this Executive Summary and in Section 8 of the report.

The report stems from recent academic thinking which has emphasised the importance of adopting a systemic approach to the analysis and support of innovation. An innovation system comprises the ‘institutions which jointly and individually contribute to the development and diffusion of new technologies, and which provides the framework within which government forms and implements policies to influence the innovation process’.

It is necessary to meet three criteria if an innovation ‘system’ is to be said to exist. First, there must be a degree of coherence between organisations agendas and orientation. Secondly, there should be widely agreed and unified objectives. Third the system must be bounded by geography, sector or technology. Whether Scotland has such an innovation ‘system’ is discussed further below.

Mapping Approach

We develop our view of the SIS in four stages:

1. Benchmarking – how do the inputs and outputs of the SIS compare to that elsewhere?

2. Functions – we first identify the key functions undertaken by organisations within the SIS. In addition, we consider two national (i.e. UK – wide) functions which also have implications for the SIS.

3. Organisations – we identify the key organisations within each function and consider their capabilities.

4. Linkages – we consider the linkages between organisations within the SIS. This analysis is at two levels – within and between functions.
**System Benchmarking**
A key comparison is that with other EU regions, and here we use data from the European Innovation Scoreboard to compare the SIS to other areas. A number of points stand out:

- In terms of those indicators dominated by public investment decisions, Scotland is in the top quartile of EU regions – levels of tertiary education, public R&D expenditure and lifelong learning. Performance on all other indicators is notably weaker.
- Business R&D spend in Scotland is in the third-quartile of the distribution of EU regions.
- Scotland has below average (third quartile) employment in medium or high-tech manufacturing although knowledge diffusion among Scottish manufacturing companies is in the second quartile of the EU distribution.
- By contrast, employment in high-tech services is above average (second quartile), while knowledge diffusion among Scottish services companies are below average (third quartile).
- Scotland is in the third quartile of EU regions in terms of the key measure of innovative outputs in the comparison – the share of sales of new-to-the-firm products in manufacturing. Scotland is in the top quartile of European regions in terms of the overall regional innovation index. This is something of a chimera, however, as the overall indicator is a composite measure based on the values of the other indicators and Scotland’s position is due largely to its strong standing in terms of human resource measures.

**Scottish Innovation System: European Regional Benchmarking**

<table>
<thead>
<tr>
<th>Regional Summary Index (36/173)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Share of sales of new-to-the-firm products in manufacturing (101/156)</td>
</tr>
</tbody>
</table>

**Summary Indicators**

- Population with Tertiary Education (11/172)
- Lifelong Learning (6/172)
- Employment in Medium High-Tech Manufacturing (82/172)
- Employment in High-Tech Services (51/172)

**Knowledge Creation**

- Public R&D Expenditure (53/157)
- Business R&D Expenditure (60/172)
- EPO High-Tech Patent Applications (65/161)
- All EPO Patent Applications (91/170)

**Knowledge Diffusion**

- Share of innovative enterprises – manufacturing (57/186)
- Share of innovative enterprises – services (56/118)
- Innovation expenditure as percentage of sales – manufacturing (61/162)
- Innovation expenditure as percentage of sales – services (57/116)

**Human Resources**

- Degree Holders (11/172)
- Life-long Learning (6/172)

**Colour Key**

- Top Quartile
- Second Quartile
- Third Quartile
- Fourth Quartile
Innovation System Anatomy
The figure below identifies a series of six functions which together contribute to the development of innovation capability within the SIS. These are:

- Function 1 – Policy Making
- Function 2 – Innovation Policy Formulation and Implementation
- Function 3 – Support and Direction of Innovation and R&D
- Function 4 – Undertaking R&D
- Function 5 – Facilitating and Conducting Knowledge Diffusion
- Function 6 - Knowledge Exploitation

In addition, the ‘region-state’ status of Scotland means it is important to recognise the influence of national and supra-national policy making and innovation support organisations in influencing the SIS. Two national functions - the national allegories of F1 and F2 – are also therefore important as are the role of EU policy in shaping and supporting innovation policy and support measures within the SIS.

Main Functions Within the SIS

![Figure 2.2: Organisational Functions Within the Scottish Innovation System](image-url)
Main Actors Influencing the SIS
The figure below provides an overview of the main organisations influencing the SIS, with organisations grouped by their main function. Scottish Enterprise National and Highlands and Islands Enterprise both span the F2 (policy formulation) and F3 (Support and direction of innovation) levels.
Knowledge generation
Knowledge generation in the SIS is undertaken primarily within the HEIs and research institutes and R&D performing businesses. The latter group is dominated by externally-owned firms. The figure below summarises our assessment of the main linkages within the knowledge-generating elements of the SIS. These are discussed in detail in Section 4.

The figure highlights the relatively strong linkages between HEIs and research institutes and their funding bodies, and their relatively good performance in terms of spin-outs, licensing and related activity.

The major weakness evident in this part of the system relates to the interaction between HEIs and the indigenous commercial base. In many respects Scottish HEIs have stronger links with externally-owned and other UK-owned firms than with indigenous SMEs, because the former are more able to absorb the knowledge generated at Scottish HEIs and maximise the economic returns from it.

Scottish Executive initiatives such as SCORE and SEEKIT are welcome attempts to overcome this disconnect but influence a relatively small proportion of firms.
**Knowledge exploitation**

Our view of linkages *within* the knowledge application function of the SIS is discussed in detail in Section 5 and summarised in the figure below (5.1).

We see relatively little evidence that many locally-owned medium and low tech firms are very actively engaged with other local companies in their innovation activity. Links between locally-owned high-tech firms, externally-owned firms in Scotland and spin-outs are stronger, with each group also having relatively strong link to externally-owned firms. We include here the Scottish Enterprise cluster and industry groups to reflect their role in network building and strengthening local linkages.

Geographical factors, and the location of higher education institutions, also create a profound distinction between the situation of firms in the Central Belt and Tayside/Grampian regions of Scotland and companies in the Highlands and Islands and the more rural areas of the Borders and Dumfries & Galloway. Firms in these areas are, in large part, excluded from any positive system dynamic within the SIS.

![Figure 5.1: Connectivity Within Knowledge Application in the SIS](image-url)
Knowledge Mediation and Sharing

This is a key function within the SIS, being the bridge between the knowledge generation and knowledge exploiting functions. This is reflected in the significant efforts have been made by Scottish Enterprise and its partners to develop linkages and networks within the SIS (Figure 6.4). Scottish Executive schemes such as SCORE and SEEKIT have also been significant in this respect.

Despite these endeavours, our discussions suggest continuing doubts about the level of horizontal connectivity between Scottish firms, and links between smaller indigenous firms and the universities. Absorptive capacity – and the low priority given by many smaller locally-owned firms to technological development – may help to explain the low level of horizontal connectivity; similar factors together with a mismatch between the technological focus of the universities and the needs of local companies may be influencing the weakness of university-industry links.

The ITIs clearly represent a major new initiative in this area, and are an imaginative and innovative intervention with the potential to have a substantial impact on innovation levels in Scotland. Our view is that at present, however, links remain relatively weak (Figure 6.4).

![Figure 6.4: Knowledge Mediation in the SIS](image-url)
Is there a Scottish Innovation System?

Within limits our view is that the SIS may be said to exhibit each of the three necessary conditions for the existence of an innovation system: coherence, unified function, and boundedness.

- **Coherence** - there is evidence of an array of organisations with common development trajectories, feedback loops and complementary competences between agents. There are, however, limits to the degree of coherence, notably in the lack of connection between the HEIs and research institutes and the indigenous SME sector. This leads to a sense of ‘imbalance’ within the system, and a need for some agenda re-alignment if greater coherence is to be achieved.

- **Unified Function** - policy documents such as *A Smart Successful Scotland* and *A Science Strategy for Scotland* provide, for the first time, a set of objectives for the SIS and beyond.

- **Bounded** – while the SIS is less evidently bounded than, say, that of the UK as a whole, it clearly is possible to determine geographical, institutional and to some extent sectoral boundaries of the system. The boundaries of the SIS are probably narrower than those of Scotland as a country, however. For example, it is clear that there are geographical areas of Scotland, notably in the Highlands and Islands, and perhaps in the Borders and Dumfries & Galloway which are effectively excluded from the system.

**Strengths of the SIS**
The knowledge generation capacity of the system is high with some key areas of strength. The commercialisation activities of the universities are effective and we see no evidence of any unwillingness to explore alternative avenues for commercialisation on the part of the universities. Scotland’s record on spin-outs, licensing and commercialisation is well up to par.

Policy innovation within the system is relatively strong. For example, the ITIs represent a major policy initiative both in terms of investment and prestige and although it is early days show some promise of making an effective contribution both to start-up activity and the commercialisation of university research. They may also play a useful ‘flagship’ role, championing innovation within the Scottish system.

R&D support measures within the SIS are fairly comprehensive with the LECs having considerable autonomy – and using it – in support of local firms. Some confusion was evident over the number of different support measures available. LECs felt a key role was helping firms to identify the appropriate support measure. We feel there is too little emphasis in the support regime on encouraging partnership between firms and, despite SCORE and SEEKIT, on encouraging university-company interaction.

**Weaknesses of the SIS**
The pattern of R&D spending in the SIS is well known, with very low levels of R&D in firms and particularly in the majority of indigenously owned firms. This is clearly a weakness of the system and limits both the capacity of firms to develop their own
knowledge bases and innovation but also no doubt hinders their ability to absorb external knowledge.

This issue is exacerbated by what we feel are low levels of innovation networking between firms and between locally-owned firms and the universities. Indeed, there is evidence of an almost complete mismatch between the output of the research active HEIs and the absorptive capacity of SMEs, and between the requirements of SMEs and the ability or willingness of HEIs to help.

Differences in the level of investment in R&D and innovation between knowledge generating and knowledge exploiting organisations within the SIS lead to a sense of ‘imbalance’ – with a university sector reminiscent of a ‘core’ EU region and a corporate sector in keeping with Scotland’s more ‘peripheral’ location. Differences in organisational agendas also lead to something of a disconnect between the university and (indigenous) corporate sectors.

The result is a lack of university-industry links and a mismatch between the type of knowledge being generated and demanded. Issues therefore arise on both sides. For the universities there is an issue in terms of more closely attuning their activities to the needs of the Scottish economy. For firms there is an issue of the priority they give to R&D and innovation investment, to upgrade their absorptive capacity and adopt a more ‘open’ stance to innovation links.

A positive model for policy development here is the Finnish organisation TEKES which combines the roles of research council and industrial development agency, providing substantial funding for collaborative research activity between HIEs and companies. It is also likely to be necessary to re-focus support for innovation at project level on collaborative or co-operative projects. SCORE, SEEKIT, and SHEFCs’ Knowledge Transfer funding are a start in this area.

Geographical factors, and the location of higher education institutions, create a profound distinction between the situation of firms in the Central Belt and Tayside/Grampian regions of Scotland and companies in the Highlands and Islands, Borders, and Dumfries and Galloway. Proximity to universities, and the potential for interaction, differ markedly – to the extent that Highlands and Islands firms and those in the Borders and Dumfries & Galloway are in many ways excluded from any positive system dynamic at the moment. A partial exception to this may be firms in the medical cluster in Inverness. In the HIE area this may be at least partly addressed by the development of the UHI Millennium Institute.
Section 1 - Aims and Objectives

1.1 Introduction
The effectiveness of Scotland’s innovation system plays a crucial if not critical role in shaping the nation’s economic performance. This report provides a benchmark assessment of the effectiveness of the Scottish Innovation System (SIS), and highlights the capabilities, role and connectivity of the key actors within the SIS. The aim is three-fold:

(a) To provide a ‘rough guide’ to the anatomy and function of the SIS with a particular focus on the capabilities, role and connectivity of the participating organisations;

(b) To identify the strengths and weaknesses of the system as it currently operates;

(c) To identify the key policy opportunities and develop some initial suggestions as to how these might be addressed.

These aims cannot, of course, be achieved solely by an examination of the internal dynamics of the SIS. Market and technological globalisation are making national and regional innovation systems ever more interdependent, emphasising the importance of external connectivity as well as that within the region. For Scotland as a region-state within the UK and EU, multi-level governance is also important with aspects of Scottish firms’ operating environment being determined in Brussels, London and Edinburgh. So, when considering the SIS, not only do we have to take into account its international linkages but also its position within the wider UK and EU innovation systems1.

Within the SIS the key foci are organisational capability and connectivity. As ‘knowledge’ becomes an ever more important competitive asset, Scotland’s ability to create new knowledge will be a key component of the effectiveness of the innovation system. Innovation, however, requires more than knowledge creation, depending also on effective interaction between those organisations generating new knowledge – largely the universities – and the business sector. Spin-out companies, for example, can play an important role in the development and diffusion of new technologies. Local knowledge sharing between firms – through networking and collaboration – also plays an important role in maximising the retained value added from innovation and spreading best practice.

1 It has been argued that EU membership constrains some policy interventions in terms of support for industry (i.e. the state aid rules), and some aspects of public technology procurement covered by the EU Directives on Public Procurement (see, for example, Edquist, Hommen and Tsipouri 2000). Balancing these constraints are potential synergies between the wider-UK and EU economies and Scotland and inward fiscal transfers. In 2001, UK government – including the Scottish agencies – funded 13 per cent of business R&D in Scotland (£65.3m of £511.6m). EU funding was £4.95m or less than 1 per cent of all business R&D spending.
Government policy – both that directly related to innovation – and in other areas (e.g. training, education) can play a crucial role in managing and integrating the SIS. The OECD have summarised the situation as follows, arguing that governments should ‘address systemic failures that block the functioning of innovation systems, hinder the flow of knowledge and technology and, consequently, reduce the overall efficiency of R&D efforts. Such systemic failures can emerge from mismatches between the different components of an innovation system, such as conflicting incentives for market and non-market institutions (e.g. enterprises and the public research sector), or from institutional rigidities based on narrow specialisation, asymmetric information and communication gaps, and lack of networking or mobility of personnel’.

1.2 Structure of the Report
We return to these issues in later sections of this report. Initially, however, we focus on understanding the recent performance of the SIS and its key actors. Our report is organised as follows:

- Section 2 provides a brief overview of the key characteristics of innovation systems. The focus is on the desirable characteristics of knowledge generating organisations (e.g. universities), knowledge exploiting organisations (e.g. firms) and the links between the two.

- Section 3 outlines high level overview of the architecture of the Scottish Innovation System, introduces the key actors and their roles and provides some structural and benchmark comparisons with other areas.

- Section 4 focuses in detail on knowledge generation within the SIS, identifying the key actors their roles and capabilities

- Section 5 focuses on the process of knowledge exploitation within the SIS and the specific role of policy in supporting innovation.

- Section 6 considers the level of interaction between organisations within the SIS and the role of policy (e.g. the ITIs) in encouraging knowledge diffusion.

- Section 7 deals with the governance and co-ordination of the SIS, concentrating on the roles of the Scottish Executive, SE and HIE.

- Section 8 synthesises the key points from the earlier discussion and provides an overview of what we see as the key strengths and weaknesses of the SIS. Policy priorities are then identified.

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1.3 **Basis of the Report**

Our report draws on a wide range of published and unpublished documentary material and statistical references. The analysis was also informed by a series of interviews with participants in the SIS. Our thinking was also helped by useful comments from members of the project Steering Committee, and to them and our informants within the system we express our thanks.

A key focus of the report was an assessment of the strength of linkages between different actors within the SIS. These linkages take many diverse forms involving exchanges of information, knowledge and funding for R&D and innovation projects. Given this diversity, any quantitative attempt to measure the strength of these linkages was beyond the scope of the current report. Our assessments of the strength of inter-organisational linkages are therefore subjective, although informed by our interviews with system participants and review of other evidence.
Section 2 - Innovation Systems - Background

2.1 Introduction
In this section we briefly review some recent perspectives on innovation systems and the factors which shape their success in generating high levels of innovative outputs. Underlying the discussion of innovation systems is an understanding of innovation as an evolutionary process in which knowledge and information are combined to generate new product and service offerings. Market processes – competition – then work to select those innovations which will be commercially successful.

R&D, technology transfer and diffusion play key roles in the innovation process, which is also influenced by the capabilities of, and linkages between, local organisations, knowledge ‘spillovers’, knowledge integration through ‘open systems architecture’, and the potentially important influence of devolved and national innovation policy.

2.2 Systemic Perspectives for Innovation
A systems perspective enables us to embrace this range of influences on innovation, and adopt a holistic view to the description and evaluation of the SIS. One definition of a national system of innovation is:

> ‘that set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technology’

Figure 2.1, taken from a recent OECD report provides one perspective on the set of organisations within an innovation system and their inter-relations. At the heart of the system are the key processes of knowledge generation, diffusion and exploitation which are shaped by the capabilities of organisations and the strength of their relationships. Supporting these activities are other aspects of the commercial, technological and regulatory environment within which firms operate. The outcome of this complex set of capabilities and linkages is national innovative capacity, a key determinant of economic performance.

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In terms of more recent academic studies, a recent article by Charles Edquist (2004) provides perhaps the most comprehensive overview of the ‘state of the art’ in thinking about regional and national innovation systems. Box 2.1 summarises his view of the development of thinking about the notion of innovation systems. While recognising that notions of ‘innovation systems’ are not formal theories, Edquist and others have argued that the ‘conceptual diffuseness’ of the innovation systems concept is one of its key strengths. This, it is argued:

- Enables innovation and learning processes to be placed at the centre of an understanding of regional and national economic development;
- Provides a holistic and inter-disciplinary framework within which the determinants of innovation can be addressed;
- Emphasises inter-dependency and non-linearities in the development of innovation capability;
- Emphasises the role of organisations and institutions (i.e. the rules of the game);
• Embraces nations’ historical and evolutionary development and particular technological and economic characteristics.

Two key issues arise in trying to operationalise the notion of an innovation system. First, what organisations or institutions are included within the system? And, secondly, what criteria should be used to assess whether any collection of organisations actually constitute a ‘system’. Debate has surrounded both questions and there are no definitive answers. Previous studies have, however, suggested some guiding principles which we propose to adopt in our assessment of the Scottish Innovation System.

Box 2.1: The development of National and Regional Innovation Systems Thinking

Edquist (2004), traces the development of the notion of innovation systems through early work by Freeman (1987) and Lundvall (1992), to the landmark book on national innovation systems edited by Nelson (1993). Edquist (2004), however, stresses the ‘contrasting approaches’ adopted to the NSI concept suggesting noting that ‘Lundvall argues that “the structure of production” and “the institutional set-up” are the two most important dimensions, which “jointly define a system of innovation” (Lundvall 1992: 10). … Nelson singles out organizations supporting R&D, i.e. he emphasizes those organisations which promote the creation and dissemination of knowledge as the main sources of innovation (Nelson 1993: 5, 9-13) … both Nelson and Lundvall define national systems of innovation in terms of determinants of, or factors influencing, innovation processes. However, they single out different determinants in their actual definitions of the concept, presumably reflecting what they believe to be the most important determinants of innovation’ (p. 4).

More recent studies, have emphasised the role of regional innovation systems (e.g. Cooke et al., 1997; Braczyk et al., 1998) and more local innovation dynamics.

2.3 Key Components of the SIS

As Figure 2.1 suggests, the outcome of the SIS is Scotland’s innovation capability. Within the SIS, however, it is possible to identify a series of six organisational functions which together contribute to the development of innovation capability. These are identified in Figure 2.2:

• **Function 1 – Policy Making** – Organisations within this function will have broad social and economic agendas and a need to balance innovation along with other policy priorities. At best such organisations will take into account

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4 Hence their definitions of national systems of innovation do not include, for example, consequences of innovation – which does not, of course, exclude that innovations, emerging in innovation systems, have tremendously important consequences for socio-economic variables such as productivity growth and employment.
the potential impact of policy decisions on national innovation capability, and will act to strengthen the framework conditions within which system development can take place. A key aspect of this element of the governance system is ensuring some consistency between local and UK and EU policy measures.

- **Function 2 – Innovation Policy Formulation and Implementation** – Organisations within this function will generally have an emphasis on regional or national economic development but may also have specific objectives relating to innovation support. The focus is on the development and design of innovation support measures and other economic development initiatives rather than their implementation. Complementarity with UK and supranational innovation and R&D support schemes is a key focus. At best these organisations adopt a systemic perspective allowing them to address systemic failures or bottlenecks and resolving gaps or mismatches in system capabilities.

- **Function 3 – Support and Direction of Innovation and R&D** - Dominated by publicly funded bodies, the key activities within this function are public support for knowledge creation, business innovation and R&D. At best these organisations provide responsive and flexible support for firms, adequate financial support for socially optimal levels of R&D and innovation activity, and are accessible to firms in each sector and sub-region.

- **Function 4 – Undertaking R&D** – This function is dominated by organisations whose corporate objectives relate to knowledge creation (i.e. researching organizations). This includes the universities, third-level colleges as well as public and industry research organisations. At best, this sub-system is populated by organizations with strong internal capabilities, dense and evenly distributed network links to other local organisations and 'open' external links to global centres of best practice (Braczyk et al., 1998). The key capabilities of R&D performing organisations for local innovation are threefold: the ability to generate new knowledge applicable to local firms or markets; the ability to capture knowledge with local applicability; the ability to provide training in R&D and innovation skills which are retained within the region.

- **Function 5 – Facilitating and Conducting Knowledge diffusion** - Intermediate organisations whose function is knowledge broking or diffusion. Key capabilities relate to the ability to identify valuable technologies or knowledge and to match this with appropriate (and local) exploitation mechanisms. Arguably such institutions play a particularly important role in mediating between knowledge generating organisations (e.g. universities) and smaller firms who may have less capability in identifying valuable technologies and a reticence to engage directly with knowledge generators.

- **Function 6 - Knowledge Exploitation** - Primarily firms linked through (vertical) local supply-chains and trading relations and (horizontal) collaborative networks. Here, the main objective is the exploitation of the knowledge-base to generate competitive products and services, and so achieve
enhanced profitability or business value. At best, firms have strong internal innovation capabilities; local supply-chain linkages are robust and characterised by strong knowledge flows between trading partners; and, horizontal collaboration networks are ubiquitous.

In addition, the ‘region-state’ status of Scotland means it is important to recognise the influence of national and supra-national policy making and innovation support organisations in influencing the SIS. In Figure 2.2 we therefore also identify two national functions which are the national allegories of F1 and F2. N1 comprises UK national policy making bodies, and N2 comprises UK bodies involved in the formulation and development of technology and innovation policy (N2). We omit any consideration of possible N3-N6 institutional functions while recognising that interactions between UK national and Scottish institutions at these levels may also be important in determining the effectiveness of the Scottish innovation system.

In addition, Figure 2.2 recognises the role of EU policy and support measures in shaping innovation policy and support measures within the SIS. EU development priorities for innovation, shaped by the Lisbon agenda, are important here, as is support for R&D and innovation in Scotland provided by the Structural Funds and Framework programmes.

**Figure 2.2: Organisational Functions Within the SIS**
2.4 Linkages and Spillovers

A particular focus of much recent debate in terms of innovation systems has been the importance of patterns of networking, linkages or association between organisations. The pattern of such links within an innovation system is important as it determines the extent of any positive ‘spillovers’ from R&D or innovation activity in the area. In other words, the extent to which R&D or innovation undertaken by one organisation positively affects either the level of innovation or performance of another organisation.

In the SIS this is particularly important due to the predominance of public sector R&D, and the concentration of private sector R&D in larger and externally-owned firms. The stronger are local linkages to these organisations, the greater will be the benefits accruing to Scottish organisations from this R&D and innovation activity.

Two sorts of knowledge spillovers occur – ‘rent’ and ‘pure’ - with the distinction being important because the mechanisms which determine the extent of each type of spillover are very different. Rent spillovers which are the result of local market transactions, may be mediated through the supply-chain, with positive effects on suppliers and/or customers. Other forms of rent spillovers may depend on the movement of research-trained staff who act as localised carriers of knowledge. The crucial determinants of the extent of rent spillovers from R&D in Scotland will therefore be the extent of intra-regional supply-chains, and the degree to which skilled staff are retained within the region. Or, put another way, the extent to which R&D conducting organisations and individuals are embedded in the Scottish economy.

Very different factors are likely to determine the extent to which Scotland benefits from pure knowledge spillovers from R&D investments, which are usually said to depend on the frequency of face-to-face contacts, and intentional and unintentional ‘leakages’ of knowledge from one organisation to another. Empirical evidence on pure knowledge spillovers is indirect, however, with the effects weakest in very small regions. Evidence from the US, however, however, suggests that Scotland is large enough geographically to capture a significant proportion of the innovation spillovers from university R&D. Specifically, in the US, spillovers from university research have a positive impact on levels of innovation in firms up to 75 miles from the location of the university. If this pattern was repeated in Scotland, firms in the Central Belt and on the East Coast would be deriving some benefit from current university R&D but there would be little positive effect in the majority of the Highlands and Islands region.

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5 Beugelsdijck and Cornet, (2001, p. 3), for example, summarise the distinction as follows: ‘Rent spillovers arise when quality improvements by a supplier are not fully translated into higher prices for the buyer(s). Productivity gains are then recorded in a different firm or industry than the one that generated the productivity gains in the first place. Rent spillovers occur in input-output relations. Pure knowledge spillovers refer to the impact of the discovered ideas or compounds on the productivity of the research endeavours of others. Pure knowledge spillovers are benefits of innovative activities of one firm that accrue to another without following market transactions’. (Beugelsdijck and Cornet, 2001, p. 3).

6 E.g. Anselin et al. (2000).

7 Beugelsdijck and Cornet (2001), however, fail to find any positive spillover effects in the Netherlands: “This study thus suggests that the Netherlands is too small a country to have proximity
2.5 What Constitutes a System?
Charles Edquist (2004) suggests three criteria which must be met if an innovation ‘system’ is to be said to exist in an area:

- **Coherence** - an innovation system will exist when the array of organisations and their relationships in a region or nation form a *coherent whole*, which has properties different from the properties of the constituents. In other words, we would expect to identify feedback systems or loops, common developmental trajectories and complementary competencies between agents.

- **Unified function** - an innovation system has a *function*, i.e. it has identifiable objectives or aims to which all elements of the system contribute. This might be evident in social partnerships (either formal or informal), agreed objectives and vision.

- **Bounded** - it must be possible to discriminate between the system and the rest of the world; i.e. it must be possible to identify the *boundaries* of the system. This could be geographic but may also be sectoral or technologically based.

play the leading role in facilitating knowledge spillovers. This conclusion might a fortiori hold for other regions of similar size.” (Beugelsdijck and Cornet, 2001, p. 17).
Section 3 - Benchmarking the Scottish Innovation System

3.1 Introduction
In this section we focus on benchmarking the institutional composition and innovation performance of the Scottish Innovation System to that in some other small countries and regions. Sections 3.2 and 3.3 begin by introducing the key actors involved in the governance and operation of the SIS. Linkages between organisations are considered in later sections. Section 3.4 compares SIS institutions to those in the Norwegian and Swedish innovation systems.

Subsequent sections focus on more quantitative benchmarking of the performance of the SIS. Section 3.5 begins with some global regional and OECD comparisons before focussing on an analysis of European Innovation Scoreboard data for European regions in Section 3.6. Finally, in Section 3.7, we consider some intra-UK comparisons based on R&D and innovation data. A particular focus in these latter comparisons is the major difference between specific industries in Scotland.

3.2 Governance within the SIS
Figure 3.1 provides an overview of the main organisations which play a part in shaping the SIS, with organisations grouped by their main function. The inclusion of EU and UK national institutions emphasises the multiple levels of governance which influence the SIS. At an EU level, Commission decisions on EU policy agendas and the scale and focus of Structural Funds and Framework programmes will both influence the funding available to Scottish organisations for investment in R&D and innovation. At a UK level, DTI and research council decisions will also shape the available funding as well as identifying national policy priorities.

At a national level, the Scottish Executive has a dual role in the SIS, having responsibility for policy formulation and development but also having a direct role in administering a number of schemes designed to enhance innovation in Scottish businesses. In terms of Figure 3.1 the Executive thus has a role in policy making (F1) and policy formulation and implementation (F2), but also in support for innovation and R&D (F3).

Scottish Enterprise plays a key role in the SIS in terms of the implementation of policy on R&D and innovation (F2), and to a lesser extent in the support and direction of R&D and innovation in Scotland (F3). The activities of Scottish Enterprise within the SIS are wide-ranging including skills development and support of cluster initiatives and incubation. In terms of innovation and knowledge exploitation specifically, Scottish Enterprise is active in four main areas: the provision of advice to firms; provision of grant funding for innovation and R&D; measures designed to help with commercial exploitation of the science base; and, the development and support of venture capital activity in Scotland. Highlands and Islands Enterprise has a broadly similar role to that of Scottish Enterprise, albeit with a more limited geographical
focus. The roles of both organisations, and an evaluation of their position within the SIS is considered in more detail in Chapter 7.

Given the range of organisations involved in the governance of the SIS, a key issue is maintaining coherence. Co-ordination between the Scottish Executive, Scottish Enterprise and HIE is generally effective, however, helped by the unifying policy agendas defined in documents such as *A Smart Successful Scotland* and *A Science Strategy for Scotland*.

### 3.3 Organisations within the SIS

In Figure 3.1, we distinguish four groups of R&D performing organisations which dominate R&D spending in Scotland: the HEIs, research institutes (e.g. Roslin, the SABRIs), foreign-owned R&D performing businesses and locally-owned R&D performing businesses. Reflecting this split, we also identify four groups of firms who differ in terms of the strength of their backwards and forwards links into the SIS. For example, locally-owned firms may be more strongly embedded in the local economy than externally-owned firms, while academic spin-outs are likely to have stronger connections to universities than small firms in more traditional sectors.

Linking or intermediate institutions have often been regarded as a weak point in UK innovation systems. We have identified five groups of actors in this area in Scotland, stimulating links both within the SIS and between SIS organisations and other actors outside the region. Scottish Executive operate the SCORE and SEEKIT schemes which stimulate collaborative activity between firms and universities. Similarly the university tech-transfer offices are able to draw on expertise from other members of the Association of University Research Industry Links (AURIL) network. The main development in this type of activity in Scotland over the last two years has of course been the development of the Intermediary Technology Institutes for Life Sciences, Information and Communication Technologies (ICT), and Energy. Their role is to identify emerging global market opportunities (where Scotland has the chance of capturing a share), and then to identify the technology platforms that will enable exploitation, and what research needs to be done to develop these to allow exploitation in Scotland.
Figure 3.1: Main Organisations Shaping the Scottish Innovation System

- **F6 Public and Private Business Operations**
  - Indigenous Medium and Low R&D Intensity
  - Foreign Branch Plants
  - Indigenous High R&D Intensity Firms
  - Foreign R&D Performers
  - Academic Spin-outs

- **F5 Institutions to Facilitate Technology Diffusion**
  - Sector and Cluster Groups
  - HEI Tech Tran Companies
  - Science Parks/Incubators
  - Innovation Relay Centres

- **F4 Performing Organisations**
  - Other Public R&D
  - Foreign Business R&D
  - HEIs and Research Institutes
  - Locally Owned Business R&D

- **F3 Facilitation and Direction of R&D**
  - Intermediary Technology Institutes
  - Scottish Executive
  - LECS
  - SHEFC
  - Private Equity

- **F2 Formulation and Operation of Policy**
  - Scottish Enterprise
  - HIE

- **F1 Policy Making Bodies**
  - Scottish Science Advisory Council
  - Scottish Executive

- **N2 UK Policy Formulation/Operation**
  - Department of Trade and Industry - DTI
  - Research Councils

- **N1 UK Innovation Policy**
  - UK Govt Macro Regu lation
  - OST
  - MOD

- **E2 EU Policy Support and Operation**
  - EU Structural Funds
  - DG Regional Policy
  - DG Enterprise
  - EU Framework Programmes

- **E1 EU Policy and Objectives**
  - EU Commission
3.4 Benchmarking SIS Institutions

It is beyond the scope of the current study to conduct a detailed benchmarking exercise of the institutional composition of the SIS. It is, however, appropriate to compare the overall structure of SIS institutions with those in some other small economies. Figure 3.2, for example, provides an overview of the innovation support institutions in Sweden, while Figure 3.3 relates to Norway. Both are small very open economies – like Scotland – although there are clear differences in terms of governance. Note that in each case while the basic functions considered are similar to those used in the SIS Figure 3.1, the labelling of the different functions (i.e. F1, F2) differ in each case. Note too that in both cases the figures relate to the institutional structure at the time of the mapping exercise (1999), and some organisational change has taken place since that date (e.g. the introduction of Vinova in Sweden in 2001).

Two overall characteristics of the institutional figures are striking. First, it is clear that the basic functions of institutions within the three innovation systems (Scotland, Norway and Sweden) are similar, encompassing the support and conduct of R&D and innovation, technology diffusion and the governance of innovation activity. Second, both the Swedish and Norwegian examples have the advantage of relating to a nation-state instead of the region-state context of Scotland. Scotland’s status inevitably makes system governance more complex with potential conflicts arising between regional and national policy agendas. In theory, at least, such conflicts are less likely with the simpler governance structure of a nation-state. Two examples may suffice. In Sweden, national public procurement has been used as an effective instrument of innovation policy in the past – something which is perhaps more difficult to operationalised in the context of the region-state (see Box 3.1).

---

**Box 3.1: Public Technology Procurement in Sweden**

The development of new industries and technologies in Sweden has historically been closely tied to the development of new domestic markets. State agencies have used public technology procurement (PTP) to create initial markets and stimulate domestic innovation (Edquist and Hommen, 2000). Since Sweden joined the EU in 1995, its public agencies have faced greater institutional obstacles in undertaking PTP initiatives under the EC Directives on Public Procurement (Edquist, Hommen and Tsipouri, 2000).

PTP is still seen, however, as having some potential as a demand-side instrument for innovation policy, using the Swedish public service sector’s comparatively large size and high quality standards as points of leverage. Most PTP projects now under way, however, are mainly characterised by incremental innovation within existing industries. The “24 X 7” project of the Swedish Agency for Administrative Development (SAFAD or Statskontoret), in which all levels of public administration have been charged with implementing ICT solutions supplied by both domestic and foreign firms to make basic services available to the public on a 24 hours per day, 7 days per week basis, provides an illustrative example.
Second, in the Norwegian system (F6) ‘public regulatory, standard-setting agencies’ are given some prominence. These are generally national powers and in the UK the majority of the regulatory framework is determined nationally. Ensuring coherence between these regulations and the specific requirements of the SIS is therefore likely to be more difficult than if the regulatory structure was determined at a regional level. A number of other contrasts are worth noting between the Norwegian and Swedish figures for 1999 and that for the SIS:

- Neither the Swedish nor Norwegian figures makes a distinction between the types of firm which is conducting R&D and innovation. In Scotland, given the strong concentration of R&D activity in externally-owned firms this is a potentially important distinction.

- In the Norwegian figure in particular (F6) the role of municipalities and county councils in the innovation system is considered. This type of organisations have not figured largely in our review of material on the SIS, perhaps reflecting differences in governance structures or the importance of the LECs within the SIS.

- Both the Norwegian and Swedish charts highlight a broader range of technology transfer or intermediate institutions than we identified in the SIS. This perhaps reflects the longer history of such public activity in the Scandinavian economies.

- In the case of the Norwegian SIS the promotion of technological entrepreneurship is highlighted although this is omitted from the Swedish institutional chart. This emphasises a slightly different view of the boundaries of the two innovation systems.
Figure 3.2: Institutional Profile of the Swedish Innovation Support System (1999)

3.5 Global Comparisons of SIS Performance

A recent report for Scottish Enterprise by Robert Huggins Associates (2005) compares the position of Scotland against a wide range of the world’s leading regional economies and also provides some summary benchmarks for Scotland.

Source: OECD, 1999, p. 36.
relative to other OECD countries. RHA’s analysis is inevitably restricted to quantitative indicators and in some cases is also restricted by the data available. In general, however, their comparison of Scotland with 161 leading regional knowledge economies emphasises the somewhat unbalanced nature of the Scottish economy; its strong public emphasis and its weaker private sector. More specifically:

- Scotland is found to have *above average* performance in terms of employment in IT and computer manufacturing and public expenditure on R&D.

- Scotland has *average* performance in terms of gross monthly earnings, economic activity rates and the employment rate.

- Scotland is *below average* for business investments in R&D, public investments in education, patenting performance, GDP per capita, and employment in medium and high-tech manufacturing and services.

Comparison with OECD economies suggests that the overall level of R&D spend in Scotland is relatively low by international standards, below that of all of the Scandinavian economies but above that in Ireland and Italy (Figure 3.4).

**Figure 3.4: Total R&D Spending by OECD and Scotland, % of GDP: 2001**

Source: Robert Huggins Associates (2005), Figure 12.
More unusual in international terms, however, is the exceptionally high contribution of higher education to total R&D spending in Scotland (Figure 3.5). In Scotland, slightly over 40 per cent of R&D expenditure is performed by business enterprise, whereas in the US, Sweden, Finland, and Japan over 70 per cent of R&D expenditure is undertaken by business. Notably too, with the exception of the Slovak Republic and Australia, Scotland had the lowest average annual growth rate of business enterprise expenditure on R&D (measured by 1995 constant prices) over the period from 1995 to 2000. This clearly indicates that Scotland’s weak position in business R&D expenditure has actually deteriorated over the period with a growing gap with other (national and regional) economies.

**Figure 3.5: Composition of R&D Spending in OECD nations and Scotland: 2001**

Source: Robert Huggins Associates (2005), Figure 13.
3.6 European Comparisons

Significant effort has been invested in recent years into benchmarking national innovation systems and policy within the EU, although less attention has focussed on comparisons of regional innovation capabilities. Quantitative indicators on innovation systems are compared in the annual European Innovation Scoreboard published by the EU Commission, while innovation policy has been the focus of both commission research projects and more academic networks. The epub network, for example, have developed an RTD Evaluation Toolbox while attempts have been made to benchmark evaluation methodologies in a range of different countries. In terms of Scotland, these national comparisons are of little very direct relevance. They do however provide an important context for more specific comparisons.

International comparisons involving the UK tend to suggest, for example, that UK levels of overall R&D spend are low by international standards. Figure 3.6, reproduced from DTI/FDES/HMT (2004), for example, highlights the decline in UK overall R&D spending as a percentage of GDP during the 1985-1998 period and the moderate recovery since. It also highlights the growth path which will be necessary to meet the 10-year target set for 2014 in the Science and Innovation Framework. Slightly less depressing is Figure 3.7, which suggests that business R&D spend in the UK, although below France and Germany, is broadly mid-range within the G7.

Figure 3.6: Total R&D Spend as share of GDP and UK Future Scenario

Source: DTI/FDES/HMT (2004), Figure 1

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8 See for example the Proceedings of a Workshop Sponsored by TEKES on Benchmarking Evaluation of Public Science and Technology Programmes in the US, Canada, Israel and Finland, 2002, TIA Consulting.
A crucial element in any international R&D comparisons, however, is the sectoral mix of the economies being compared. Indeed, such structural adjustments are much more important in R&D and innovation than in other areas (productivity, international trade) where they are much more common. This is because sectoral disparities in technology intensity are much more extreme than those between productivity levels, say, and so structural effects are even more important. For example, comparing UK data for 2-digit manufacturing industries for 1998, 1999 and 2000 suggests a coefficient of variation for GVA per employee between sectors of 0.9-1.1. For the same sectors (for 1999, 2000 and 2001) the coefficient of variation for R&D intensity (i.e. R&D as a proportion of sales) is 2.6-2.8.

The importance of such effects is illustrated by a shift-share analysis comparing business R&D intensity in the UK and other countries reported in DTI/FDES/HMT (2004), Table 4. This shows that on a like for like basis UK firms were actually investing more than their German counterparts in R&D but that German firms were concentrated in more R&D intensive sectors. This type of consideration will be important when comparisons are made between levels of business R&D investment in Scotland and the UK, for example.

The European Innovation Scoreboard 2004, for example, suggests that the UK innovation system is ‘moving ahead’ in terms of aspects of human capital investment and ICT spending but ‘falling behind’ in terms of employment in medium/high-tech manufacturing and R&D investment (Figure 3.8).

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9 Sources: R&D in UK Businesses, Data for 2001, Business Monitor MO14, Table 24; Labour Productivity Measures from the Annual Business Inquiry, ONS, Newport, Table 6.
Other studies have focussed in more detail on the structure and orientation of innovation policy in different countries. EU (2003), for example, provides an indication of leading practice in innovation policy formulation and emphasises nations’ very different approaches to innovation policy. This is illustrated neatly by the composition – inevitably approximate – of each country’s innovation budget allocated to the different types of policy initiative (Table 3.1). The pattern in the UK mirrors relatively closely that in the US with support balanced roughly equally between fiscal incentives for innovation, subsidy measures and ‘integrated packages of support’. Other countries suggest different approaches with Finland emphasising direct support measures (subsidies and loans), the Netherlands emphasising fiscal incentives and France placing more emphasis on direct credit and loan support. The UK therefore is somewhere in the ‘middle’ in terms of its policy-mix towards innovation at the moment using a balanced mix of innovation support measures. It is important to acknowledge, however, that this position is relatively new, with the increased emphasis being placed in recent years on R&D tax credits. Previous periods would have seen the UK with an emphasis more like that of the US with a greater emphasis on subsidy schemes.
Table 3.1: Percentage of Innovation Budgets By Policy Measure

<table>
<thead>
<tr>
<th></th>
<th>Finland</th>
<th>France</th>
<th>Netherlands</th>
<th>UK</th>
<th>New Zealand</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tax facilities</td>
<td>0</td>
<td>29</td>
<td>54</td>
<td>35</td>
<td>94</td>
<td>24</td>
</tr>
<tr>
<td>Subsidy Schemes</td>
<td>47</td>
<td>25</td>
<td>22</td>
<td>29</td>
<td>0</td>
<td>42</td>
</tr>
<tr>
<td>Credits and Loans</td>
<td>51</td>
<td>32</td>
<td>10</td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Brokerage and</td>
<td>20</td>
<td>0</td>
<td>11</td>
<td>4</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>bridging Institutions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated Packages</td>
<td>0</td>
<td>14</td>
<td>3</td>
<td>30</td>
<td>6</td>
<td>25</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: EU (2003), Table 5.1

Among European innovation systems the UK system therefore emerges as being characterised by a broad range of innovation support policies.

Specific inter-regional comparisons of innovation capability in the EU are less common with perhaps the most comprehensive being the study by Hugo Hollanders published as part of the 2003 European Innovation Scoreboard (EU, 2003). This uses a series of 14 indicators to compare the human resource, knowledge creation, knowledge diffusion and overall capabilities of EU regions’ innovation systems. (These are defined in detail in Annex 1 which also provides an indication of the index methodology). For each indicator EU (2003) essentially defines a European regional league table, and Figure 3.9, provides a summary indication of the position of Scotland. A number of points stand out:

- Scotland is in the top quartile of European regions in terms of the overall regional innovation index. This is something of a chimera, however, as the overall indicator is a composite measure based on the values of the other indicators and Scotland’s position is due largely to its strong standing in terms of human resource measures.

- Scotland is in the third quartile of EU regions in terms of the key measure of innovative outputs in the comparison – the share of sales of new-to-the-firm products in manufacturing.

- Scotland is in the top quartile of EU regions in terms in those indicators dominated by public investment decisions – levels of tertiary education, public R&D expenditure and lifelong learning. Performance on all other indicators is notably weaker.

- Business R&D spend in Scotland is in the third-quartile of the distribution of EU regions.

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Notably no such study was published as part of the 2004 Innovation Scoreboard. This is disappointing as EU (2003a) is based on CIS2 data and national information for CIS3 has been available for around 3 years. Contacts with Eurostat have suggested, however, that no EU wide regional analysis of CIS3 is planned, although UK regional comparisons are possible.
Scotland has below average (third quartile) employment in medium or high-tech manufacturing although knowledge diffusion among Scottish manufacturing companies is in the second quartile of the EU distribution.

By contrast, employment in high-tech services is above average (second quartile), while knowledge diffusion among Scottish services companies are below average (third quartile).

Two broad conclusions can be drawn from this regional benchmark comparison. First, relative to other EU regions Scotland does not suffer from any lack of public investment in either knowledge creation or skill building. Second, there is a marked inconsistency between public and private investments in R&D and innovation, with notably lower levels of private investment. Unfortunately, the level of innovative outputs (i.e. the knowledge diffusion indicators) seem to be constrained by the lower levels of private R&D investment. It is true, however, that the knowledge diffusion indicators for manufacturing put Scotland in the second quartile of EU regions while levels of business R&D investment are in the third quartile. This may suggest the effectiveness of policy initiatives to support innovation activity in these firms.
### 3.7 UK Comparisons

As the EU regional comparison suggests the national profile of R&D spending in Scotland differs markedly from that in the UK as a whole. In overall terms in 2002, R&D investment in Scotland was 89-96 per cent of the UK level depending on the measure used (Table 3.2). Business investment, however, was much lower in relative terms (58-62 per cent), while public investment in R&D (including both higher education and direct investment by government) was disproportionately high - 66 per cent above the UK average level (Table 3.2). Notably also, a higher proportion of Scottish business R&D spending is in US owned companies than in the UK as a whole.

#### Table 3.2: R&D Spending in Scotland and the UK - 2002

<table>
<thead>
<tr>
<th></th>
<th>Scotland</th>
<th>UK</th>
<th>Scotland UK=100</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total R&amp;D Spend 2002</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>As % of GDP</td>
<td>1.75</td>
<td>1.83</td>
<td>95.6</td>
</tr>
<tr>
<td>Per head of population</td>
<td>289</td>
<td>325</td>
<td>88.9</td>
</tr>
<tr>
<td><strong>Public R&amp;D Spend 2002</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>As % of GDP</td>
<td>0.98</td>
<td>0.59</td>
<td>166.1</td>
</tr>
<tr>
<td><strong>Business R&amp;D Spend 2002</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>As % of GDP</td>
<td>0.77</td>
<td>1.24</td>
<td>62.1</td>
</tr>
<tr>
<td>Per Employee - all sectors</td>
<td>390</td>
<td>669</td>
<td>58.3</td>
</tr>
<tr>
<td>Per Employee - manufacturing</td>
<td>2093</td>
<td>2885</td>
<td>72.5</td>
</tr>
<tr>
<td>Per Employee - services</td>
<td>64</td>
<td>185</td>
<td>34.6</td>
</tr>
<tr>
<td><strong>Nationality of Ownership (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td>32</td>
<td>62</td>
<td>51.6</td>
</tr>
<tr>
<td>US</td>
<td>54</td>
<td>23</td>
<td>234.8</td>
</tr>
<tr>
<td>Other EU</td>
<td>11</td>
<td>10</td>
<td>110.0</td>
</tr>
<tr>
<td>Rest of World</td>
<td>4</td>
<td>5</td>
<td>80.0</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100.0</td>
</tr>
</tbody>
</table>

*Source: Scottish Executive, 2004.*

In terms of innovation outputs the most recent information derives from the CIS-3 and the proportion of manufacturing firms engaging in a range of innovative activities are summarised in Table 2.3. Here, firms are said to be innovation active if they are engaged in one or more of the previous five innovation activities. Scotland generally ranks somewhere towards the upper-middle of the UK regional rankings but there are some notable differences. Overall, for example in terms of innovative activity, Scotland ranks 5/12. Process innovation seems more common, however, with Scotland ranking 3rd, compared to 7th for product change. Most critically, however, Scotland achieves its lowest ranking 11/12 for cooperation agreements on innovation activities suggesting relatively low levels of networking and technology diffusion.
Table 3.3: Innovation by Manufacturing Firms: CIS 3 Data

<table>
<thead>
<tr>
<th>Product Innovator</th>
<th>Process Innovator</th>
<th>Co-operation agreements on innovation activities</th>
<th>Innovation not yet completed or abandoned</th>
<th>Innovation related expenditure</th>
<th>Innovation active</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scotland</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>23.1</td>
<td>22.3</td>
<td>8.3</td>
<td>21</td>
<td>42</td>
<td>55</td>
</tr>
<tr>
<td>Northern Ireland</td>
<td>25.7</td>
<td>20.2</td>
<td>16.9</td>
<td>27.3</td>
<td>47.6</td>
</tr>
<tr>
<td>North East</td>
<td>27.6</td>
<td>25.5</td>
<td>11.8</td>
<td>28.8</td>
<td>53.3</td>
</tr>
<tr>
<td>North West</td>
<td>19.6</td>
<td>19.7</td>
<td>9.4</td>
<td>15.8</td>
<td>42</td>
</tr>
<tr>
<td>Yorks and Humber</td>
<td>21.4</td>
<td>15.1</td>
<td>7.4</td>
<td>18.8</td>
<td>41.4</td>
</tr>
<tr>
<td>East Midlands</td>
<td>23.3</td>
<td>21.6</td>
<td>12.3</td>
<td>20.4</td>
<td>39.6</td>
</tr>
<tr>
<td>West Midlands</td>
<td>20.5</td>
<td>22</td>
<td>12.9</td>
<td>21.3</td>
<td>43.8</td>
</tr>
<tr>
<td>Eastern</td>
<td>24.3</td>
<td>20.5</td>
<td>12.6</td>
<td>19.5</td>
<td>44.1</td>
</tr>
<tr>
<td>London</td>
<td>19.1</td>
<td>18.3</td>
<td>5.9</td>
<td>17.2</td>
<td>37.3</td>
</tr>
<tr>
<td>South East</td>
<td>25.9</td>
<td>20.9</td>
<td>11.1</td>
<td>23.8</td>
<td>49.5</td>
</tr>
<tr>
<td>South West</td>
<td>26.6</td>
<td>19.9</td>
<td>11.6</td>
<td>22.3</td>
<td>45.9</td>
</tr>
<tr>
<td>Wales</td>
<td>27.5</td>
<td>23.4</td>
<td>12.8</td>
<td>19.8</td>
<td>44.3</td>
</tr>
<tr>
<td>UK</td>
<td>23</td>
<td>20.4</td>
<td>10.7</td>
<td>20.5</td>
<td>43.6</td>
</tr>
</tbody>
</table>

As indicated earlier, however, comparing aggregate levels of R&D investment or innovation can be misleading due to differences in sectoral composition, and may also disguise strongly varying sectoral relativities. Scottish Executive (2004) provides a good account of the Scotland/UK relativities in this respect and these are summarised in Table 3.4 for 2002. For some sectors, however, no relativities can be calculated due to disclosure rules. Sectors fall into four main groups:

(a) A group of sectors where per capital investments in R&D in Scotland is less than a quarter of the UK average. This group includes: transport engineering (6.8 per cent); motor vehicles and parts, 12.0 per cent; office machinery and computers, 14.1 per cent; food products and tobacco, 18.4 per cent; and, pulp paper and printing etc., 24.3 per cent.

(b) Three sectors in which R&D investments in Scotland were around four-fifths of the UK level – textiles, clothing etc. electrical machinery and apparatus and radio, television and communication equipment.

(c) Two sectors where investment was broadly in line with the UK level – machinery and equipment and chemicals and pharmaceuticals.

(d) Three further sectors where R&D investment levels in Scotland were markedly above the UK level – fabricated metal products, furniture and other manufactured goods and precision instruments.
Table 3.4: R&D Expenditure in Manufacturing: Scotland and the UK - 2002

<table>
<thead>
<tr>
<th>Industry Category</th>
<th>Scotland £ per employee</th>
<th>UK £ per employee</th>
<th>Scotland UK=100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Products and beverages: Tobacco</td>
<td>119</td>
<td>648</td>
<td>18.4</td>
</tr>
<tr>
<td>Textiles, clothing and leather products</td>
<td>78</td>
<td>98</td>
<td>79.4</td>
</tr>
<tr>
<td>Pulp, paper and paper products; Printing and publishing:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood products</td>
<td>21</td>
<td>85</td>
<td>24.3</td>
</tr>
<tr>
<td>Refined petroleum products and coke oven products:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Processing of nuclear fuel</td>
<td>na</td>
<td>10167</td>
<td>Na</td>
</tr>
<tr>
<td>Chemicals, Man-made fibres, Pharmaceuticals</td>
<td>16630</td>
<td>16664</td>
<td>99.8</td>
</tr>
<tr>
<td>Rubber and plastic products</td>
<td>na</td>
<td>294</td>
<td>Na</td>
</tr>
<tr>
<td>Other non-metallic mineral products</td>
<td>na</td>
<td>374</td>
<td>na</td>
</tr>
<tr>
<td>Basic Metals</td>
<td>na</td>
<td>500</td>
<td>na</td>
</tr>
<tr>
<td>Fabricated metal products</td>
<td>205</td>
<td>165</td>
<td>123.9</td>
</tr>
<tr>
<td>Machinery and equipment</td>
<td>2437</td>
<td>2465</td>
<td>98.8</td>
</tr>
<tr>
<td>Office machinery and computers</td>
<td>503</td>
<td>3563</td>
<td>14.1</td>
</tr>
<tr>
<td>Electrical machinery and apparatus</td>
<td>2744</td>
<td>3168</td>
<td>86.6</td>
</tr>
<tr>
<td>Radio, television and communication equipment</td>
<td>9700</td>
<td>11052</td>
<td>87.8</td>
</tr>
<tr>
<td>Precision instruments</td>
<td>5971</td>
<td>3408</td>
<td>175.2</td>
</tr>
<tr>
<td>Motor vehicles and parts</td>
<td>537</td>
<td>4494</td>
<td>12.0</td>
</tr>
<tr>
<td>Transport Equipment</td>
<td>1106</td>
<td>16148</td>
<td>6.8</td>
</tr>
<tr>
<td>Furniture: Other manufactured goods</td>
<td>361</td>
<td>250</td>
<td>144.4</td>
</tr>
<tr>
<td>Recycling</td>
<td>na</td>
<td>216</td>
<td>na</td>
</tr>
<tr>
<td>All Manufacturing</td>
<td>2093</td>
<td>2885</td>
<td>66.4</td>
</tr>
</tbody>
</table>

Notes and Sources: R&D Spending, Table 2, Scottish Executive (2004). Employment, ABI for Great Britain and Scotland (from Nomisweb), ABI report from DETI in Northern Ireland.
Section 4 - Knowledge Generation in the SIS – R&D Performing Organisations

4.1 Introduction
This section focuses on those organisations, institutions and companies which generate and disseminate the scientific and other knowledge on which innovative activity in Scotland is based. The nature, extent and density of the links between these organisations and their links with Scotland’s commercial base are also considered. Clearly, not all of the knowledge which underpins innovative activity is generated from within Scotland: indeed, the ability to identify, absorb and use world-class knowledge generated elsewhere can be an important attribute for a relatively small, open economy. However, the key focus of this section is on Scotland’s internal ability to generate, disseminate and use scientific knowledge.

4.2 Key Actors Engaged in Knowledge Generation
Section 3 of this report highlighted the fact that, compared both to the UK and other countries, public R&D expenditure in Scotland is relatively high and business R&D expenditure relatively low. This is illustrated in Table 4.1 which indicates that public expenditure on R&D (government establishments and HEIs) accounts for approximately 60% of total R&D expenditure in Scotland, with business R&D accounting for approximately 40%.

Table 4.1: Gross expenditure on R&D in Scotland, 2000-2002

<table>
<thead>
<tr>
<th></th>
<th>Scotland (£m, 2000)</th>
<th>As % of Scotland</th>
<th>Scotland (£m, 2001)</th>
<th>As % of Scotland</th>
<th>Scotland (£m, 2002)</th>
<th>As % of Scotland</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&amp;D performed within businesses (BERD)</td>
<td>400</td>
<td>3.5</td>
<td>512</td>
<td>4.2</td>
<td>640</td>
<td>4.9</td>
</tr>
<tr>
<td>R&amp;D performed in government establishments</td>
<td>238</td>
<td>11.2</td>
<td>226</td>
<td>12.4</td>
<td>238</td>
<td>13.6</td>
</tr>
<tr>
<td>R&amp;D performed in HEIs</td>
<td>440</td>
<td>12.1</td>
<td>510</td>
<td>12.6</td>
<td>581</td>
<td>13.2</td>
</tr>
<tr>
<td>Total</td>
<td>1,078</td>
<td>6.2</td>
<td>1,248</td>
<td>6.7</td>
<td>1,459</td>
<td>7.6</td>
</tr>
</tbody>
</table>

Source: Scottish Executive (2003), Overview of Higher Education in Scotland – Baseline Report Part V

Each of the three segments above is outlined briefly in turn.

4.2.1 Business R&D in Scotland\(^{11}\)
As indicated in Table 4.1 above, business enterprise R&D (BERD) in Scotland accounts for a less than proportionate amount of UK BERD, although the gap with the

\(^{11}\) Much of the data and analysis in this section comes from Scottish Executive (2004), Business Enterprise Research and Development in Scotland 2002.
UK has narrowed since 2000. The value of BERD undertaken in Scotland in 2002 was £640 million, 4.9% of the UK total. R&D expenditure in Scotland nearly doubled in real terms between 1997 and 2002, compared to a real terms increase of 22% in the UK. In 2002 Business R&D expenditure was equivalent to 0.77% of GDP in Scotland, compared with 1.24% of GDP in the UK.

**Figure 4.1: Business expenditure on R&D by sector, 1994-2002**

![Diagram showing R&D expenditure by sector from 1994 to 2002.](image)

*Note: Expenditure is presented in constant prices, using a general GDP deflator.*


Figure 4.1 shows Scottish business R&D expenditure for selected products between 1994 and 2002. Nearly two thirds of Scottish BERD takes place in just three product groups: pharmaceuticals, electrical machinery and precision instruments. These are the only sectors which have a significantly higher than average share (i.e. higher than 4.9%) of UK business R&D. R&D expenditure on pharmaceuticals increased nine fold in real terms between 1997 and 2002: about half of the total increase in Scottish R&D spending during the period 1994-2002 is accounted for by the increase in the pharmaceuticals sector. By contrast, Scotland’s share of BERD is particularly low in: Food Products, Beverages and Tobacco products (2.1%); Computer and related activities (2.0%); Other Transport Equipment & Aerospace (excluding motor vehicles) (0.8%); Agriculture, hunting and forestry: Fishing (0.4%); Motor vehicles and parts (0.2%). Scotland’s share of UK R&D expenditure is low in the services sector at 2.6% of the UK total.
Table 4.2: Business expenditure on R&D by business sizeband, 2002

<table>
<thead>
<tr>
<th></th>
<th>Total Expenditure</th>
<th>0-99 employees % of total</th>
<th>100-199 employees % of total</th>
<th>400+ employees % of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scotland</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Of which:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturing</td>
<td>640</td>
<td>109 17%</td>
<td>175 27%</td>
<td>356 56%</td>
</tr>
<tr>
<td>Services</td>
<td>552</td>
<td>38 10%</td>
<td>151 27%</td>
<td>343 62%</td>
</tr>
<tr>
<td>UK</td>
<td>13110</td>
<td>1539 12%</td>
<td>1922 15%</td>
<td>9249 71%</td>
</tr>
<tr>
<td>Of which:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturing</td>
<td>10140</td>
<td>839 8%</td>
<td>1411 14%</td>
<td>7891 78%</td>
</tr>
<tr>
<td>Services</td>
<td>2645</td>
<td>688 26%</td>
<td>490 19%</td>
<td>1202 45%</td>
</tr>
</tbody>
</table>


Table 4.2 shows that, while large businesses perform most R&D, there are significant differences between Scotland and the UK. In particular, a higher proportion of R&D in Scotland is done by small and medium-sized enterprises (SMEs). The difference is much larger for services products: more than two thirds of R&D in 2002 was undertaken by small firms (a quarter in the UK). This issue relates to the issue of indigenous absorptive capacity among SMEs discussed later.

Table 4.3: Business expenditure on R&D by country of ownership, 2002

<table>
<thead>
<tr>
<th>Performed in Scotland</th>
<th>Expenditure</th>
<th>£m</th>
<th>percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country of ownership</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scotland</td>
<td>157</td>
<td>25%</td>
<td></td>
</tr>
<tr>
<td>Rest of the UK</td>
<td>43</td>
<td>7%</td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>348</td>
<td>54%</td>
<td></td>
</tr>
<tr>
<td>Other EU</td>
<td>69</td>
<td>11%</td>
<td></td>
</tr>
<tr>
<td>Rest of the World</td>
<td>23</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>640</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Performed in UK</th>
<th>Expenditure</th>
<th>£m</th>
<th>percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country of ownership</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td>8127</td>
<td>62%</td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>3016</td>
<td>23%</td>
<td></td>
</tr>
<tr>
<td>Other EU</td>
<td>1287</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Rest of the World</td>
<td>680</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>13110</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>


Table 4.3 shows that one quarter of business R&D in Scotland is undertaken by Scottish-owned enterprises. Over half of R&D in Scotland is undertaken by firms headquartered in the USA, and almost 70% by foreign-owned enterprises. This, of course, reflects the ownership pattern of the large R&D expenditure industries highlighted earlier, coupled with the fact that foreign-owned establishments tend to be larger than their Scottish-owned counterparts.
4.2.2 Research Performed in Government Establishments

Much of the research carried out by government establishments in Scotland is in the field of agricultural and biological research funded by the Scottish Executive Environment and Rural Affairs Department (SEERAD). A large proportion of the research (more than 85% by value) supported by SEERAD is carried out within its eight main research providers (see Box 4.1).

The main research providers receive core funding from SEERAD Science and Research Group to support identified research activities. Capital funding is also made available to them by SEERAD Science and Research Group. They also compete for funding from other sources in the public and private sectors.

**Box 4.1: SEERAD-funded Research Institutes**

Scottish Crop Research Institute is a major centre for research on agricultural, horticultural and industrial crops in particular potatoes, barley and soft fruit.

Rowett Research Institute carries out research on how nutrition can prevent disease, improve human and animal health and enhance the quality of food production in agriculture.

Moredun Research Institute carries out research on diseases of livestock with a particular focus on small ruminants.

Macaulay Land Use Research Institute carries out research to meet the needs of sustainable rural development and environmental management in Scotland and similar areas worldwide.

Hannah Research Institute carries out research focused on the achievement of lifelong health and the prevention of lifestyle related diseases in Scotland and to contribute to the health and success of the next generation.

Biomathematics and Statistics Scotland provides support and research on mathematics and statistics to the other SEERAD research organisations.

Scottish Agricultural College carries out research to meet the needs of the land based industries focusing on sustainable crop and livestock systems, animal health and welfare, economics, socio-economics and the environment. SAC also provides education to diploma, degree and post-graduate levels and a wide range of other training. SEERAD Science and Research Group fund education activities and provide funding for ‘public good’ advice commissioned by SEERAD.

Royal Botanic Garden Edinburgh The role and status of RBGE is distinct. It is a Non-Departmental Public Body and its functions are defined by the National Heritage (Scotland) Act 1985 including research, education, collections and public access.

There are two other research institutes which receive significant amounts of public money for research in Scotland. The Roslin Institute is a major UK centre for animal bioscience. However, it is funded principally by the Biotechnology and Biological Sciences Research Council (BBSRC) and receives minimal funding from the Scottish Executive or other Scottish sources. The Scottish Association for Marine Science (SAMS) carries out research and education in marine science. It is a Collaborative Centre of the Natural Environment Research Council, and an academic partner in the UHI Millennium Institute.

Table 4.4: Research Income at Scottish Research Institutes

<table>
<thead>
<tr>
<th>Research income from Scottish Executive (£000)</th>
<th>Other research income (£000)</th>
<th>Total research income (£000)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SEERAD Main Research Providers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hannah Research Institute</td>
<td>6,960</td>
<td>4,640</td>
</tr>
<tr>
<td>Moredun Research Institute</td>
<td>6,770</td>
<td>2,408</td>
</tr>
<tr>
<td>Macaulay Land Use Research Institute</td>
<td>7,150</td>
<td>2,030</td>
</tr>
<tr>
<td>Rowett Research Institute</td>
<td>6,960</td>
<td>2,784</td>
</tr>
<tr>
<td>Scottish Crop Research Institute</td>
<td>9,488</td>
<td>1,841</td>
</tr>
<tr>
<td>Scottish Agricultural College</td>
<td>5,633</td>
<td>6,614</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>42,961</strong></td>
<td><strong>20,317</strong></td>
</tr>
<tr>
<td><strong>Other Research Institutes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roslin Institute</td>
<td>---</td>
<td>12,570</td>
</tr>
<tr>
<td>SAMS</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>42,961</strong></td>
<td><strong>32,887</strong></td>
</tr>
</tbody>
</table>

1 Time period varies from 2001 to 2003.
Source: Various

4.2.3 Research Performed in HEIs in Scotland

Scotland’s 21 HEIs comprise 14 universities (including the Open University in Scotland), two arts colleges, one university college, one college of FE, one conservatoire, the University of Highlands and Islands Millennium Institute (UHIMI) and the Scottish Agricultural College. All are funded by The Scottish Higher Education Funding Council (SHEFC), with the exception of the Scottish Agricultural College which is funded by SEERAD.

Research income in HEIs accounts for c.40% of total R&D expenditure in Scotland (see Table 4.1) and is generated from two main sources. SHEFC allocates quality research funding (QR) based on Research Assessment Exercise outturns, and HEIs receive research grants and contracts from a variety of other sources, mainly on a competitive basis. In 2002-03 Scottish HEIs received 11.4% of total UK HEI
funding, and 13.4% of all UK research income. Since Scotland has 8.5% of UK population and 11.6% of HEIs, this indicates considerable strength in attracting research income; in 2001-02 Scottish HEIs attracted 50% more research council funding per head of population than English HEIs.

Table 4.5 shows the amount of research income generated in each HEI. The eight pre-1992 universities account for 95% of total research funding, and just two universities, Edinburgh and Glasgow, account for over 50%.

Table 4.5  Research income at Scottish HEIs, 2001-02

<table>
<thead>
<tr>
<th>University</th>
<th>Research income from funding Councils (£000)</th>
<th>Research grants &amp; contracts (£000)</th>
<th>Total research income (£000)</th>
<th>Total income (£000)</th>
<th>Research income as a share of total income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>141,013</td>
<td>308,956</td>
<td>449,969</td>
<td>1,564,053</td>
<td>29%</td>
</tr>
<tr>
<td>The University of Edinburgh</td>
<td>42,290</td>
<td>87,833</td>
<td>130,123</td>
<td>314,068</td>
<td>41%</td>
</tr>
<tr>
<td>The University of Glasgow</td>
<td>28,599</td>
<td>76,379</td>
<td>104,978</td>
<td>264,845</td>
<td>40%</td>
</tr>
<tr>
<td>The University of Dundee</td>
<td>13,330</td>
<td>38,493</td>
<td>51,823</td>
<td>130,776</td>
<td>40%</td>
</tr>
<tr>
<td>The University of Aberdeen</td>
<td>11,239</td>
<td>33,554</td>
<td>44,793</td>
<td>124,961</td>
<td>36%</td>
</tr>
<tr>
<td>The University of Strathclyde</td>
<td>17,032</td>
<td>22,672</td>
<td>39,704</td>
<td>158,765</td>
<td>25%</td>
</tr>
<tr>
<td>The University of St Andrews</td>
<td>8,550</td>
<td>17,287</td>
<td>25,837</td>
<td>73,224</td>
<td>35%</td>
</tr>
<tr>
<td>Heriot-Watt University</td>
<td>7,113</td>
<td>12,451</td>
<td>19,564</td>
<td>82,069</td>
<td>24%</td>
</tr>
<tr>
<td>The University of Stirling</td>
<td>5,818</td>
<td>7,036</td>
<td>12,854</td>
<td>65,609</td>
<td>20%</td>
</tr>
<tr>
<td>Glasgow Caledonian University</td>
<td>1,296</td>
<td>3,294</td>
<td>4,590</td>
<td>76,430</td>
<td>6%</td>
</tr>
<tr>
<td>The Robert Gordon University</td>
<td>1,555</td>
<td>1,625</td>
<td>3,180</td>
<td>73,402</td>
<td>4%</td>
</tr>
<tr>
<td>Napier University</td>
<td>1,238</td>
<td>1,868</td>
<td>3,106</td>
<td>65,415</td>
<td>5%</td>
</tr>
<tr>
<td>Queen Margaret University College</td>
<td>679</td>
<td>1,834</td>
<td>2,513</td>
<td>22,241</td>
<td>11%</td>
</tr>
<tr>
<td>The University of Paisley</td>
<td>411</td>
<td>1,903</td>
<td>2,314</td>
<td>49,095</td>
<td>5%</td>
</tr>
<tr>
<td>University of Abertay Dundee</td>
<td>491</td>
<td>1,224</td>
<td>1,715</td>
<td>29,430</td>
<td>6%</td>
</tr>
<tr>
<td>Edinburgh College of Art</td>
<td>689</td>
<td>854</td>
<td>1,543</td>
<td>13,131</td>
<td>12%</td>
</tr>
<tr>
<td>Glasgow School of Art</td>
<td>521</td>
<td>558</td>
<td>1,079</td>
<td>12,442</td>
<td>9%</td>
</tr>
<tr>
<td>RSAMD</td>
<td>36</td>
<td>91</td>
<td>127</td>
<td>8,150</td>
<td>2%</td>
</tr>
</tbody>
</table>

1  Excludes Bell College, UHIMI, OU, SAC
2  Includes technology transfer funds

However, research income is only one measure of knowledge generation. Some indication of the quality of research activity can be obtained from the results of the 2001 Research Assessment Exercise (RAE), which graded subject areas on a 7 point...
scale in terms of their research output and other research activity. Analysis of the 2001 RAE\(^\text{12}\) suggests areas of particular strength and some areas of weakness:

- Several areas of research are particularly strong in Scotland, including Biological Sciences, Veterinary Science, Computer Science, History, Applied Mathematics and Middle Eastern and African studies;

- Almost one quarter of all submitted Scottish staff full-time equivalents (FTEs), some 1,300 researchers, are in the 11 subject areas that have an average RAE rating of 5 or above. Five of these subject areas are generically Biological or Medical Science based (Hospital-based Clinical subjects, Biological Sciences, Clinical Laboratory Sciences, Pharmacy and Veterinary Sciences. Two of these – Hospital-based Clinical subjects and Biological Sciences, representing 650 staff FTEs – performed significantly better in Scotland than the UK average;

- The Biological Sciences submissions from Scottish HEIs account for 16.2 per cent of the UK total. They are significantly more highly rated than the UK average (on the seven-point scale);

- The subject areas which performed below the UK average constitute 46 per cent of the research active staff located in Scottish institutions. These subject areas include: Social Policy and Administration; Food Science and Technology; Economics and Econometrics; Chemical Engineering; Business and Management Studies; Other Studies and Professions Allied to Medicine; Environmental Sciences; and Nursing.

### 4.3 The Efficiency of Knowledge Generation

There are two aspects to the efficiency of knowledge generation activities within any innovation system: the ability of the business sector to turn R&D expenditure into innovative outputs, and the knowledge transfer and commercialisation performance of the publicly-funded research providers (HEIs and research institutes).

The first of these was briefly dealt with in Section 3. Data from a variety of sources pointed to a modest performance in terms of innovation performance in Scotland, particularly in terms of a key output metric, the proportion of new-to-the-firm products in manufacturing.

The second area – knowledge transfer and commercialisation – involves the dissemination and exploitation of knowledge developed by the public research base (see Box 4.2). Information on this activity was gained both from official sources\(^\text{13}\) and from interviews with commercialisation and IP directors at two of Scotland’s largest HEIs and a major research institute.

\(^\text{12}\) Scottish Executive (2003), *Overview of Higher Education in Scotland – Baseline Report Part V*

\(^\text{13}\) The main data source is the annual *Higher Education Business and Community Interaction Survey* (HEBCIS) published by SHEFC.
Box 4.2 Knowledge Transfer and Commercialisation

Knowledge transfer is the dissemination and exploitation of the outputs of HE – research, knowledge, skills, expertise or ideas – to achieve economic, educational, social, and cultural benefits for society. It is broader than using the intellectual property generated in HEIs for economic benefit – or its ‘commercialisation’. Commercialisation – spinout and start-up companies and the patenting and licensing of new ideas – is currently the highest profile form of knowledge transfer. The term is now understood more widely to include activities such as staff and student placements with industry, providing continuing professional development outwith the student body and providing consultancy to business. In its widest sense, knowledge transfer also includes teaching and learning undertaken on taught programmes at all levels in HEIs and the predominantly vocational sub-degree programmes in further education colleges (FECs).


In terms of knowledge transfer and its contribution to economic development in Scotland, there is evidence of some difference in attitude and behaviour between Scottish and UK HEIs (Figure 4.2). In 2002-03 Scottish HEIs put more emphasis on technology transfer generally than their other UK counterparts, but put much less emphasis on supporting SMEs than other UK HEIs. Since SMEs largely represent the indigenously-owned sector in Scotland, this is a potentially important issue. HEI and research institute interviewees repeatedly stressed that the reason they did not have more interaction with local SMEs was because of a lack of demand from the commercial sector. A very consistent picture was drawn of the relative thinness of the SME sector in Scotland in terms of its scientific and managerial competence, and the lack of absorptive capacity in the sector to make use of the (often world-class) research being carried out in Scottish universities.
This was reinforced in the interviews with regard to the commercialisation side of HEI activity. HEIs in Scotland do not regard local SMEs as being good vehicles for licensing activity, which is a major part of the commercialisation of the public Scottish research base. Much of the world-class research done in Scotland (e.g. in biosciences) lends itself naturally either to the creation of spin-off companies or to licensing with major companies, often international in scope, which have the capacity and expertise to maximise royalty revenues. By contrast, the most likely links with Scottish SMEs are in consultancy work linked to specific projects and problems raised by companies. Broadly speaking, while the universities welcome this activity and do charge for it, consultancy is often regarded more as quasi-public good, knowledge transfer activity rather than commercial activity per se. The larger research-oriented universities in particular claim to find it difficult to inform SMEs of the relevant research activity which is being undertaken within HEIs, and to interest them in it (see Box 4.3 with regard to the SRIS initiative).

It should be noted that there is little evidence that Scottish HEIs under-perform in commercialisation activity generally. According to HEBCIS figures for the last three academic years (2000-01 to 2003-04), in all the major areas of commercial activity (consultancy, income from collaborative research, disclosures and patents, licenses, spin-offs) Scottish HEIs performed roughly on a par with the UK sector as a whole, and tended to outperform UK institutions in terms of patenting. The other publicly-funded research institutes also appear to perform on a par with their UK counterparts in this form of activity. There is also some evidence that Scottish HEIs may perform commercially as well as US institutions. Analysis by the Director of Research Services at Edinburgh University suggests that, per dollar of research income, the eight pre-1992 universities in Scotland perform as well as the top 11 US HEIs in terms of disclosures, patents, licenses, patents and spinouts, and have done so

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for at least the last decade. The key difference between Scotland and the US, according to this analysis, is not quality of commercialisation and knowledge transfer, but scale of operation.

The available data suggest that the perception that there is a ‘problem’ of a lack of knowledge transfer and commercialisation among Scottish HEIs is probably unfounded. There is, however, a disconnect between the high-quality research being carried out in Scotland and the indigenous SME sector. Much of the research activity in Scotland’s HEIs is geared towards a highly sophisticated worldwide community of science users, relatively few of which are to be found among indigenous enterprises in Scotland. The earlier discussion of business R&D in Scotland also points to a lack of absorptive capacity, especially among SMEs. Tables 4.2 and 4.3 above show that only 30% of Scotland’s already limited level of business R&D is carried out in Scottish-owned companies, and that a relatively high proportion of R&D in Scotland is done by small and medium-sized firms. Obviously these points are related; Scottish-owned firms tend to be smaller than foreign-owned enterprises. It therefore seems likely that both the amount and standard of domestic R&D carried out by Scottish business is low: the picture is of a domestic business sector which lacks the indigenous research capacity to absorb much of the research output of an internationally successful HEI research community.

Box 4.3 lists the current policy initiatives to help exploit the knowledge base of publicly-funded research in Scotland. Interviews with representatives of HEIs and research institutes suggested that two of these initiatives, the Knowledge Transfer Grant and Proof of Concept funding, were very highly regarded and greatly welcomed as addressing a perceived gap in the knowledge transfer system. More sceptical opinions were expressed about other initiatives, however. For reasons outlined above, initiatives to enhance the links between Scottish SMEs and HEIs or to improve the rate of commercial spinouts were thought unlikely to succeed until the relatively poor absorptive capacity of the existing indigenous commercial base had been addressed.
**Box 4.3 Public Policy Initiatives to Exploit the Knowledge Base of Scottish HEIs and Research Institutes**

*SHEFC’s Knowledge Transfer Grant* funds the long-term underpinning platform of skills and capacity that allows HEIs to engage more effectively with wider society, and is allocated through a formula which provides incentives to do so productively. It is set at £9.5 million for 2004-05.

*Proof of Concept* funding supports the development of technology from Scotland’s HEIs and other research centres towards being marketable products. The fund administered by Scottish Enterprise totals £33 million over a six year period (1999-2005). Additional funding from ERDF and Scottish Enterprise in 2004 took the total value of the fund to £49 million, and it has supported over 170 projects so far.

*Enterprise Fellowships* are funded by Scottish Enterprise and delivered by the Royal Society of Edinburgh, and help individual academic researchers to develop spin-out companies.

*Technology Ventures Scotland* (TVS) was set up in 2000 to provide a strategic and overarching role in encouraging the commercialisation of Scotland's Science and Technology base. It is a multi-stakeholder organisation in the field of R&D commercialisation in Scotland. It provides the leading forum for senior level representation to engage in informed dialogue with Ministers, senior civil servants and business leaders on the commercialisation of Scotland's R&D capabilities.

*Connect Scotland* is a technology-business network, bringing together experienced entrepreneurs and business angels, business professionals, venture capitalists, aspiring entrepreneurs and entrepreneurial academics. It helps to nurture the creation, development and growth of technology enterprise throughout Scotland, so that emerging technology companies become investor-ready, and to facilitate the transfer of technology from the science base to new and existing firms. SHEFC provided the funds in order to role out this initiative across the whole of Scotland.

*The Scottish Institute for Enterprise* aims to encourage a greater number of business start-ups from within Scotland’s universities and boost the commercial potential of university science and technology research. The institute aims to enhance, encourage and develop entrepreneurship education, and to improve the network of support for commercialisation which exists across Scotland’s university science, engineering and technology base. SHEFC will be providing core funding to the institute from 2004-05.

*Scottish Research Information System (SRIS)* is a searchable web-based database containing data on research activity in Scottish HEIs, which is aimed at potential users of research.

Scottish Enterprise has set up three *Intermediary Technology Institutes (ITIs)* in Life Sciences, Energy, and Techmedia (Communications Technologies and Digital Media). This is a planned investment amounting to £450 million over 10 years which aims to address the relatively low levels of corporate research and development in Scotland. These are discussed in more detail in section 5.

Source: Updated from Scottish Executive (2003), *Overview of Higher Education in Scotland – Baseline Report Part V*
4.4 Key Results and Mapping

A number of key points emerge from our evaluation of knowledge generation activity within the SIS:

- Business R&D expenditure in Scotland is low (especially in services), concentrated in a few sectors, and performed mainly by foreign-owned enterprises.

- Scottish HEIs are highly research-active, perform above the UK average in terms of research grant income, and have a worldwide reputation in certain key areas such as biosciences.

- Scottish HEIs and research institutes perform well with respect to knowledge transfer and commercialisation. However, there is a disconnect between their top-quality research and the requirements and absorptive capacity of a scientifically weak indigenous SME sector. This is offset somewhat by Scottish Enterprise initiatives such as the ITIs and incubators and Scottish Executive schemes such as SCORE and SEEKIT.

- Some public policy initiatives such as Proof of Concept have helped close identified gaps in the exploitation of publicly-funded knowledge generation, but the fundamental mismatch between the research capability of the top HEIs and the absorptive capacity of Scottish SMEs is unlikely to be solved by simple policy initiatives.
Figure 4.3 summarises our assessment of the strength of the main linkages within the knowledge-generating elements of the SIS based on our informant interviews and our review of existing studies. The figure highlights the relatively strong linkages between HEIs and research institutes and their funding bodies, and their relatively good performance in terms of spin-outs and related activity. The major weakness evident in this part of the system relates to the interaction between HEIs and the indigenous commercial base. In many respects Scottish HEIs have stronger links with externally-owned and other UK-owned firms than with indigenous SMEs, because the former are more able to absorb the knowledge generated at Scottish HEIs and maximise the economic returns from it. Scottish Executive initiatives such as SCORE and SEEKIT are welcome attempts to overcome this disconnect but influence a relatively small proportion of firms.
Section 5 - Knowledge Exploitation and Application

5.1 Introduction

Repeated themes of earlier sections of this report – documented in detail in Chapter 3 - have been the relatively low level of R&D activity in Scottish firms, the concentration of R&D activity in externally-owned companies and low levels of connectivity between knowledge generating and applying organisations. These observations suggest two key questions. First, why is the level of business R&D low in Scotland, particularly in locally-owned firms? Secondly, how effective are current support measures in helping firms to overcome the barriers to undertaking R&D and innovation? Section 5.2 provides a summary of firms’ responses to these questions drawing on a previous study for the Scottish Executive on the factors shaping firms’ R&D decisions and a series of interviews conducted for this report. Section 5.3 considers the more specific issue of spin-outs and barriers to commercialisation from the Scottish universities. Section 5.4 reviews and illustrates the main drivers of innovation in Scottish firms. Verbatim material from our own interviews with Scottish firms is included in Annex 2.

5.2 R&D and Innovation in Scottish Firms

Chapter 3 provides a detailed comparative perspective on levels of R&D and innovation in Scottish firms compared to those in other UK and EU regions. This emphasises the concentration of R&D activity in high-tech sectors and among externally-owned manufacturing plants. A recent SE study investigated firms’ reasons for undertaking R&D and innovation and the pros and cons of operating in Scotland. What emerges is that Scottish firms’ main motivation for undertaking R&D is to develop new products followed by adapting or improving existing products with the aim of increasing market share. Among firms undertaking R&D, the quality of innovative behaviour seems relatively high with 73 per cent of those companies undertaking R&D producing something that is new to the market rather than just new to the firm. This measure of the ‘novelty’ of R&D activity is seen even in traditional manufacturing companies with 58 per cent of innovation new to the market.

When asked about their views of Scotland as a location for R&D a balance emerged between issues related to peripherality and distance from main markets and the potential for links to research institutions and grant support. Multi-national plants, in particular, despite having above average levels of R&D investment in Scotland stressed a preference for a location closer to their company HQ. Difficulties in undertaking R&D in Scotland were related to; raising venture capital as tends to be a focus on firms in the South East; transport links to Europe and the US, and difficulties with recruitment of skilled personnel in areas outwith the Central Belt. In the oil and gas industry, locational factors were said to be important, and in bioscience too firms suggested difficulties in attracting suitable personnel. In the latter sector particular problems were associated with the lack of experienced staff in the industry, and what
some firms considered unrealistic salary expectations on the part of newly qualified graduates and post-graduates.

More generally, however, factors limiting R&D and innovation activity tended to be market related – linked to risk, returns and opportunities rather than input availability. This suggests that the structural characteristics of the firm – sector, size, ownership, previous R&D experience – are the main determinants of levels of R&D activity as they determine the technological opportunities and the contextual and environmental effects. For example, staff in small firms related difficulties in keeping in touch with developing technologies and difficulties in creating an internal climate to support innovation. Other firms stressed what they perceived as the weakness of the culture of innovation and entrepreneurship in Scotland. Some firms related to this to the weakness of entrepreneurship and innovation in Scottish companies generally. Others focussed more on what they perceived as difficulties with aspects of the environment for innovation, particularly in terms of market size and weak local demand for innovative products and services.

A key issue is therefore the extent to which participation in the SIS can either mitigate the risks of R&D and innovation activity, or help firms to identify new potential opportunities. In terms of the boosting the rewards from R&D and innovation government support was seen by firms as an important encouragement for R&D and innovation, both through grants and tax incentives as well as loans. Specific schemes were remembered and had been important for some firms. One small company told us:

‘SMART and SPUR have been good for us, and have given us real ability to punch above our weight. Even big companies find it hard to pick winners- these schemes allow small companies to have a portfolio of technologies – this type of incremental investment is very important in facilitating a firms growth rather than stagnation. Overall we have received good help from SMART / SPUR etc, and people from LEC and SE are usually very interested and supportive’.

Such comments were accompanied by a feeling that LEC staff were generally helpful if sometimes lacking in specific expertise. Firms stressed the importance of the LECs in providing guidance as the appropriateness of different support measures, help in developing linkages and practical support in achieving innovation objectives. The LECs ability to help was sometimes said to be limited by the attitude and openness of Scottish businesses themselves.

Less clear was any consistent view among firms as to the national objectives, role and focus of Scottish Enterprise. In some cases this related to uncertainty over the strategy or focus of Scottish Enterprise, in other cases the breadth of Scottish Enterprise’s task was seen as too broad leading to a confusion of objectives. Doubts were also expressed about the co-ordination of support for innovation within the SIS, both in terms of the LECs and the role of university technology transfer offices. A minority of firms also highlighted what they saw as conflicts between the different support measures available for innovation.

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In terms of identifying new possibilities for innovation, links with HEIs was seen as important, particularly by traditional manufacturers. However, the SE survey also made clear that in many cases there was:

‘… only a weak link between single-site manufacturers and the universities. Business links with academia is an area where it appears there is market failure as there are companies expressing a desire to make links with universities to enable them to either start or increase their R&D capabilities but they do not know how to go about making such links. When links exist between universities and business it is clear this is mutually beneficial and that the level of R&D undertaken can increase. It is also clear that, from both the survey and the case studies, those companies without an existing link to a university found it difficult to establish one’.

This view was reemphasised by our company interviews, even among firms linked to incubators and science parks. In theory these firms should have ready access to their local HEI; in practice the ‘value added’ from a science park location was often said to be limited. It is important to acknowledge, however, that for some firms the development of a university link is not on the agenda. One firm indicated that:

‘We have quite deliberately not engaged with any universities, we don’t see the tangible benefit of doing this at the moment- we are a small firm focused on our own objectives. At the moment we are at full capacity with our own intellectual development, and the internal R&D that these ideas need. Of course, that doesn’t mean this is something we will never do as things change’.

5.3 Start-ups and Spin-outs

Section 4.3 indicated that commercialisation and spin-out activity from Scottish HEIs and research institutes is at least on a par with UK and some international comparators. Our discussions with firms suggested strongly contrasting views about the strength of existing support for spin-out and start-ups in Scotland. Some firms had a strong positive view about Scottish Enterprise support for spin-outs etc. while others suggested the need for alternative approaches by SE to supporting new firms.

Key issues were seen as the need to provide more assistance with IP protection and early stage development of new products. A number of firms reflected on the difficulty of the spin-out process. Other firms emphasised difficulties with the control of IP, or situations where the university or the inventor was unwilling to release control of the enterprise. A key theme was the practical difficulty of drawing together individuals with technical knowledge and those with commercial expertise. Some firms stressed, for example, the tendency for academic inventors or to lack business or marketing expertise. One commonly suggested solution was trying to link those with new product ideas and business expertise – e.g. the use of ‘surrogate’ entrepreneurs.

5.4 Overview and Mapping

Our previous discussion and the comments of firms reported here stress the importance of inter-connectivity within the SIS for innovation. Links to the LECs, the
HEIs and Science Parks are important external links between the knowledge application functions of the SIS and other elements of the system. These links between knowledge generation and knowledge application are discussed in more detail in Section 6. Section 7 deals with system governance and co-ordination.

Our view of linkages within the knowledge application function of the SIS is summarised in Figure 5.1 based on our informant interviews and our review of existing studies. In general, we see relatively little evidence that many locally-owned medium and low tech firms are very actively engaged with other local companies in their innovation activity. This is suggested both by some of the quotes referenced earlier and data from the Community Innovation Survey. Links between locally-owned high-tech firms, externally-owned firms in Scotland and spin-outs are stronger, with each group also having relatively strong link to externally-owned firms. There are of course links from each group of firms to other organisations within the SIS (e.g. LECS, HEIs) but these are discussed in subsequent sections. We have included the Scottish Enterprise cluster/industry groups in Figure 5.1, however, to reflect their role in strengthening local links and networks.
6.1 Introduction

In this section we describe the organisations involved in technology transfer and diffusion within the SIS. This element of UK innovation systems has often been argued to be particularly weak compared to that of more strongly developed innovation systems\(^\text{15}\). In the German system, for example, the positive knowledge transfer role of the Fraunhofer Institutes has been widely noted mediating between university researchers and small to medium sized companies\(^\text{16}\).

In the SIS, technology transfer and knowledge diffusion have been promoted through a number of policy initiatives and activities. First, the development of cluster and industry groups is now well established, although developments in this area continue (e.g. the current development of the medical products and research cluster in Inverness). Second, business incubation is a well established element of the Scottish industrial development scene, as are science parks. Third, and more recent are the Intermediary Technology Institutes, and these are a key focus of this section.

6.2 Cluster and Industry Groups

Cluster and industry groups have been an established element of the Scottish industrial development scene for some years now, with dedicated Scottish Enterprise teams responsible for cluster co-ordination and support. This type of initiative has a potentially significant role to play in the development of an effective innovation system, by promoting effective innovation networks and ‘association’, by strengthening local supply chains and hence local spillovers, and by encouraging developmental synergies between local firms. Enhanced knowledge generation may therefore be encouraged through joint ventures or partnerships and enhanced knowledge diffusion or sharing may be stimulated by strengthened networks or inter-firm linkages.

The Cluster initiative is broadly based covering most of the main sectors in Scotland, with the aim of identifying and developing synergies and strengthening and developing linkages. Cluster maps have been developed by some teams highlighting existing and aspirational supply and knowledge linkages. These are useful in providing an illustration at industry level of some of the points made earlier about connectivity within the SIS, particularly in terms of university-industry links.

The food team for example, based in Aberdeen developed linkage maps for 1999/2000. These are included here as Figures 6.1 and 6.2. Key points suggested by the 1999 situation were:

\(^{15}\) See for example the account of the UK national innovation system by Walker (1993) in the book edited by Richard Nelson (1993)

\(^{16}\) See for example the chapter on Baden-Wurttemberg by Heidenreich and Krauss (1998) in Braczyk et al. (1998).
Figure 6.1: Scotland’s Food and Drink Cluster 1999

Figure 6.2: Scotland’s Food and Drink Cluster 2010
The fragmentation of the Scottish food industry and the weakness of many links between organisations within the local food sector

- the existence of strengths within the sector – in value added processing, in the universities, in the whisky industry – but the lack of connectivity between these areas of strength and other weaker elements of the system.

- Generally low levels of investment in R&D and innovation and low levels of collaboration and cooperation.

This illustrates some of the points made in Section 3 about the weakness of the links between the Scottish universities and the largely indigenously owned food sector, something which the cluster team hoped to overcome by 2010.

Developed at a similar time, a cluster map developed by the Optoelectronics team highlighted a slightly different picture (Figure 6.3). This pointed to the positive role of Scottish universities in contributing to device design and display technology, and strong process links between universities and system integrators based in Scotland (e.g. Cisco, Motorola, Polaroid). These links were identified as of ‘medium’ strength by the cluster team, and were again identified as a focus for development. Again this reinforces the impression given in Section 4 with the universities more strongly linked to local, externally-owned high-tech firms rather than smaller indigenous companies.

**Figure 6.3: Scotland’s Optoelectronics Cluster - 2000**

6.3 The Intermediary Technology Institutes

The Intermediary Technology Institutes (ITIs) were announced in 2003 by Scottish Enterprise. Their objective is to identify emerging global market opportunities in Life Sciences, Information and Communication Technologies (ICT), and Energy, and the technology platforms that will enable their exploitation. Research may then be commissioned – either from Scottish universities or elsewhere – to enable Scotland to
take advantage of new market opportunities. The sectors targeted by the ITIs are recognised as being among Scotland’s strongest in terms of global competitiveness:

- In Life Sciences, transgenics, stem cells and cancer treatments are clear comparative strengths.

- In ICT, Scotland has a strong software knowledge-base, reflected in the earlier initiative to network this to production of leading Large Scale Integration chip-design mediated by the Alba Centre. More recently, Scotland’s mobile telephony content industry has shown global competitiveness, notably in computer games software engineering.

- In energy, not only the oil industry but in energy conservation and alternative energy sources.

Each ITI has a budget of £15 million per year for which an annual Operational Plan is produced within the framework of a rolling three-year Strategic Plan. Each ITI has a Board of Directors and they have a joint Executive Committee of the three ITIs plus the Chief Executive Officer (Operations). Reporting to Scottish Enterprise is thus embedded in these structures, with the main interface person being the Board Chairman, although links also exist with key contacts within the Scottish Enterprise managerial structure as appropriate. Thus the ITIs are arm’s length bodies, funded by Scottish Enterprise, but with a high degree of independence.

The intended role of the ITIs within the SIS is integrative – linking together important sections of the SIS which have hitherto been perceived as rather disconnected. Three specific kinds of disconnection which the ITIs are addressing are identifiable.

- First, having identified potential market opportunities the ITIs are seen as having a potential role in enabling innovative personnel, mainly in universities, to take inventions from the laboratory bench to the pre-commercialisation phase. This function will complement other initiatives such as the ‘Proof of Concept’ fund and the ‘Co-investment Fund’.

- Second, the ITIs are also seen as having a role in extending the scope of university research and commercialisation activity towards new market-opportunities.

- Third, within their industries the ITIs are also seen as providing commercially relevant support services, overcoming potential rigidities or inadequacies in more traditional innovation support measures.

The manner in which these activities are being pursued differs between the ITIs, but some common strategic principles can be identified. First, each of the ITIs is adopting a focus on ‘platform technologies’ which have some qualities of ‘ubiquity’, i.e. they are likely to be pervasive in their impact rather than being confined to a specific sector. In ICT, for example, broadband wireless technologies, content creation tools, human-computer interfaces, and networked sensor technologies all have wide
potential application\textsuperscript{17}. Second, the ITIs have adopted an explicit approach to \textit{cluster-building in their areas of influence, reinforcing} Scottish Enterprise’s longstanding cluster approach. As indicated earlier, the motivation is straightforward – to intervene to enable businesses to gain from complementarities, collaborations and ‘knowledge spillovers’ especially where related firms operate in geographical proximity. Third, Finally, by providing a new focus for networking within the SIS, the ITIs are seeking to overcome barriers to connectivity arising from the existence of established ‘communities of practice.’ This objective is being pursued through two main routes: formally, by the development of membership events including universities, firms and individuals; and, secondly – and more informally - through one-to-one meetings with key actors in the ‘system’ such as Deans of University Schools, investors, anchor firms to create trust, reputation and communication channels among innovation constituencies. Despite their recent development, the ITIs are already performing valuable roles in the spheres in which they operate – new connections are being made and alternative development models and processes are being explored. What is clear, however, is that the development through the ITIs of sectoral or industry groupings (clusters) with global status is likely to be a generational process.

\textbf{6.4 Business Incubation}\textsuperscript{18}

At the time of the most recent Scottish Enterprise review of incubation activity in Scotland (2001) there were 57 incubator facilities, focussing primarily on the development of technology-based companies with high growth potential\textsuperscript{19}. These incubators have a potentially important role in supporting the development of such high-tech firms, and also in encouraging networking between start-up companies. Incubators may also be seen as a property-based initiative in less developed areas to try and stimulate start-up and small business development. The majority of incubators in Scotland are sector specific: 32\% in the software sector; 25\% in the biotechnology/bio-medical/healthcare sector and 19\% are technology-related. Somewhat surprisingly, however, only around a third of all business incubators in Scotland are linked to (one or more) of the universities, although each of the universities has some incubator link. Some - like those in Glasgow and Aberdeen – are based on science parks, others are more stand alone institutions.

\textsuperscript{17} Thus, as a case in point, the \textit{OECD STI Outlook 2004} reports that the following are the R&D Priorities of several OECD members: Canada – Biotechnology, ICT, Nanotechnologies; Japan – Life Sciences, ICT, Nanotechnology; S. Korea – Electronics & Biotechnology; Mexico – ICT, Biotechnology; New Zealand – Biotechnology, ICT and Creative Industries. Meanwhile in the USA, more ‘pervasive’ R&D Priorities have been set such as ‘Networking IT’ involving large-scale networking; high confidence software systems; software design productivity; social, economy & workforce applications; and human-computer interaction. Other ‘pervasive’ priorities include; complex systems, climate, water & hydrogen, homeland security, and long term nanotechnology applications, e.g. in information processing.

\textsuperscript{18} This section draws primarily on a review of business incubation in Scotland conducted for Scottish Enterprise.

\textsuperscript{19} There is no agreed definition of a business incubator but a working definition is …an organisation that helps in the creation and accelerated development of start-up and early-stage businesses by providing them with a bundle of facilities and services which can include: workspace on terms appropriate to start-up companies; access to specialist facilities/equipment; business development support services (e.g. support with business planning, marketing, financing, mentoring); common office services; access to business networks.
Development of the incubator network has been actively supported by Scottish Enterprise with expenditure of £17.9m from 1997-2001 (Table 6.1). Subsequent to their development, the SE review suggested that Scottish Enterprise involvement was generally less direct. In certain specific cases, however, there was close integration between the SEN and incubator management teams (e.g. Software, biotechnology).

The diversity of the rationale, objectives and range of activities of Scottish incubators have been emphasised. ‘Many projects have been developed in isolation and failed to integrate economic development objectives; many have become property projects driven by occupancy levels and rental income rather than strategic economic objectives or business needs’. Levels of business support offered also vary widely from ‘low’ to more than 60% of executives’ dedicated effort.

Table 6.1: SE Funding for Incubation Activity, 1997 to March 2001

<table>
<thead>
<tr>
<th>Project</th>
<th>Total Value</th>
<th>SE Contribution (£)</th>
<th>SE as % of Total</th>
<th>Space Created (sq ft net)</th>
<th>Units Created (Number)</th>
<th>SE Spend per sq ft (£)</th>
<th>SE Spend per Unit (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Value</td>
<td>23,294,000</td>
<td>17,924,000</td>
<td>65 (average)</td>
<td>192,196</td>
<td>315</td>
<td>186 (average)</td>
<td>104,631 (average)</td>
</tr>
</tbody>
</table>

This diversity means that it is probably inappropriate to discuss incubation in a "national" context. ‘There is no national approach to incubation, rather there is an agglomeration of local approaches. The approach across the network is largely unstructured and fragmented with no apparent common direction or cohesion’. What is important, however, is that the incubation function has an established place in the SIS, playing an important support role in the commercialisation of university research, supporting spin-out from established companies and, in more rural areas, acting as a focus for the delivery of business support services.

6.5 Discussion and Mapping

Through the cluster initiatives, support for incubation and science parks, and most recently the ITIs, significant efforts have been made by Scottish Enterprise and its partners to develop linkages and networks within the SIS (Figure 6.1). Scottish Executive schemes such as SCORE and SEEKIT have also been significant in this respect, although our view is that the overall system effect of these measures has been relatively weak due to the small proportion of firms involved.

Despite these endeavours, our discussions with key informants, and our review of existing studies, suggest continuing doubts about the level of horizontal connectivity
between Scottish firms, and links between smaller indigenous firms and the universities. Absorptive capacity – and the low priority given by many smaller locally-owned firms to technological development – may help to explain the low level of horizontal connectivity; similar factors together with a mismatch between the technological focus of the universities and the needs of local companies may be influencing the weakness of university-industry links.

The ITIs clearly represent a major new initiative in this area, and are an imaginative and innovative intervention with the potential to have a substantial impact on innovation levels in Scotland. Our view is that at present, however, links remain relatively weak (Figure 6.1). Key points which may contribute to the future success of the ITIs are:

(a) Through the ITIs, the implementation of innovation policy is now, for the three fields in question, in the hands of experts intimate with the dynamics of specific global markets and inclined towards future thinking rather than extrapolating the past.

(b) Second, the development of the ITIs suggest a welcome awareness of a systemic approach to policy, with a focus on the development of system competencies or ‘platform’ technologies rather than a focus on supporting specific innovation projects.

(c) Third, the ITIs suggest that there is recognition that with outsourcing to China, India and elsewhere now encompassing R&D, Scotland needs further to rebuild its efforts to become a research industry location, selling advanced solutions to global clients all over the world. For this to happen, ‘knowledge entrepreneurship’ capabilities require nurturing across the board.

We therefore believe that the ITIs form a useful bridgehead to the future with the potential to develop new innovative and economic strengths in elements of the SIS. In our view they will do relatively little, however, to integrate the Scottish university sector and smaller indigenous firms across the range of sectors. This disconnect is therefore likely to remain a significant element of the SIS without some more specific policy attention. This is discussed in more detail in Section 8.
Figure 6.4: Knowledge Mediation in the SIS

Key

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<tr>
<th></th>
<th>Strong</th>
<th>Weak</th>
<th>Medium</th>
<th>Very Weak</th>
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<tr>
<td>Red</td>
<td>Strong</td>
<td>Weak</td>
<td>Medium</td>
<td>Very Weak</td>
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<tr>
<td>Magenta</td>
<td>Medium</td>
<td>Very Weak</td>
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7.1 Introduction
This section provides an overview and critique of the roles played by the organisations which have central roles in innovation policy making and formulation in Scotland: the Scottish Executive, Scottish Enterprise (SE) and Highlands and Islands Enterprise. In terms of the key components of the SIS identified in Figure 3.1, these three organisations are the only ones which have a role in three separate areas: policy making (F1), policy formulation and implementation (F2) and support and direction of R&D and innovation (F3).

7.2 The Scottish Executive
7.2.1 The Role of the Executive in the SIS
The Scottish Executive has a dual role in the SIS, taking a lead role in policy formulation and development, and administering a number of schemes designed to enhance innovation in Scottish businesses. In terms of Figure 3.1 the Executive thus has a role in policy making (F1) and policy formulation and implementation (F2), but also directly in support for innovation and R&D (F3).

The general framework for policy was developed in 2001 with the publication of *A Smart Successful Scotland*, which laid out a policy agenda to develop and enterprising, knowledge-based economy. The role of science, technology and innovation in increasing competitiveness and improving Scotland's economic performance is stressed in the Executive's enterprise strategy, and highlights two areas in particular:

- **Science strategy** (F1 policy making; F2 policy formulation) was highlighted with the publication of *A Science Strategy for Scotland* (2001). This advocated a focus on targeting areas of scientific strength in Scotland and appropriately funding them, as well as maximising their positive economic impact by increasing the effective exploitation of the scientific research base. The document also involved the establishment of the Scottish Science Advisory Committee (SSAC) in 2002, with a remit to “provide advice to Scottish Executive Ministers on science strategy, policy and priorities, and to allow the Scottish Executive to make effective use of available scientific advice, knowledge and techniques in formulating and implementing policies to support the full range of its objectives”. An evaluation of the SSAC and Scotland’s science strategy is given in the next section.

- **Business and innovation support** (F3 support for innovation and R&D) involves a range of financial support measures for innovation and related activities (see Box 7.1). Three of these programmes (SMART: SCOTLAND,
SPUR and SPUR+) are grant schemes targeted at promoting innovation, are part funded by the European Regional Development Fund and have equivalents throughout the UK. By contrast, SCORE and SEEKIT are specific Scottish Executive initiatives, aimed at encouraging greater co-operation between SMEs and the Scottish science base.

### Box 7.1: Scottish Executive Innovation Support and Funding

- **SMART:SCOTLAND**  
  Successful applicants receive funding of 75 per cent of the cost of carrying out a technical and commercial feasibility study lasting between 6 and 18 months. The maximum award is £50,000. SMART:SCOTLAND winners who successfully complete their projects and who need more help to develop a pre-production prototype can get further support through the SPUR programme.

- **SPUR**  
  SPUR grants help small to medium sized enterprises (SMEs) to develop new products and processes involving a significant technological advance for the UK industry or sector concerned, up to pre-production prototype stage. Awards can be made to independent businesses and groups with less than 250 employees.

- **SPUR+**  
  The programme provides grant support for expensive leading edge technology development in areas such as telecommunications and biotechnology. To be eligible for support, projects must normally involve eligible project costs of at least £1 million. Assistance of up to £500,000 at 35 per cent of eligible costs is available to support development up to pre-production prototype stage.

- **SCORE**  
  The SCORE programme is designed to support R&D projects jointly undertaken between public sector research bodies (such as Higher Education Institutes (HEIs), Research Institutes, NHS Trusts) and Scottish SMEs. Under this scheme, an SME or group of SMEs with a specific technical problem or need can assign a significant part of the required scientific and technological research to a public sector research body.

- **SEEKIT**  
  The SEEKIT programme is designed to support projects that will promote co-operation in R&D and knowledge transfer between small to medium sized enterprises (SMEs) and the Scottish public sector science base. Applications are invited from public bodies, such as Universities, Research Institutes, Technology Transfer Organisations and NHS Trusts.

### 7.2.2 Evaluation of the Science Strategy and SSAC

As indicated above *A Science Strategy for Scotland* (2001) developed a framework to inform the development of science policy in Scotland, and to help its economy meet the challenge of global competition. The goals of the strategy resonate with the goals of other agencies involved in Scotland’s innovation system. They include: strengthening the science base, improving exploitation, training more scientists, promoting science in society, and utilising science in evidence-based policy formulation and implementation.
One of the key achievements of the science strategy was the establishment of the Scottish Science Advisory Committee (SSAC) as an independent source of advice to the newly appointed Minister of Science. SSAC exists under the wing of the Royal Society of Edinburgh but is funded by the Scottish Executive. Work across as many as 55 topic areas identified in the science strategy has proven challenging, but SSAC’s existence has assisted formation of an internal group to co-ordinate matters relating to science policy within the Scottish Executive. This has contributed to an improvement in science governance within the administration though not necessarily its innovation governance. This is because the group receiving advice remains a Scottish Executive group with no representation from Scottish Enterprise or the Scottish Higher Education Funding Council.

In 2004, the first report of SSAC was published\textsuperscript{20} and its theme reflected its earlier concerns, namely better integration of science governance to assist improved innovation. A number of other points were also emphasised:

- the need for organisational boundaries to be viewed as conduits not barriers to knowledge flows;
- the desirability of strong links between actors within the SIS and UK and EU networks; and
- the importance of local networks and forums involving scientists, policy makers, funders and users of science.

In each case the recognition of the need for increased levels of association is positive, and is consistent with the aspiration of Scottish Enterprise’s cluster and sectoral groups as well as the ITIs. Less positive is the rather science-centric view espoused by the SSAC and its emphasis on out-dated notions like ‘picking winners’ and the ‘linear model’ view of innovation, with little recognition that innovation is very often stimulated by demanding lead users. In this sense there may be some value in a reformed \textit{Science & Innovation Advisory Council}, which would be a real organisational innovation confronting science with the users and policy makers from outside the Scottish Executive and science community. Such an organisation could perform an important integrating service further assisting the formation of a well-functioning innovation system in Scotland.

\textbf{7.3 Scottish Enterprise}

\textbf{7.3.1 The Role of Scottish Enterprise}

Scottish Enterprise impacts on the SIS at various levels. It has the key role in the implementation of policy on R&D and innovation (F2), and to a lesser extent in the support and direction of R&D and innovation in Scotland (F3). The activities of Scottish Enterprise within the SIS are wide-ranging including skills development and the support of the cluster initiatives and incubation activities described in the previous chapter. In terms of innovation and knowledge exploitation specifically, Scottish Enterprise is active in four main areas:

\textsuperscript{20} \textit{Science Matters: Making the Right Connections for Scotland} (SSAC), 2004
1. **Advice.** SE provides advice to companies on product and process development and innovative ways of working, and on the funding available for innovative projects.

2. **Funding.** Although most public support for innovation in businesses comes from the Scottish Executive (see Box 7.1), Scottish Enterprise provides some direct funding through its Small Company Innovation Support, administered through the LECs, and R&D Plus, designed to support the research activities of large companies with an R&D presence, or a planned R&D presence, in Scotland.

3. **Exploiting the scientific knowledge base.** Scottish Enterprise funds or co-funds several of the public policy initiatives summarised in Box 4.3, including the Proof of Concept programme, Enterprise Fellowships and Technology Ventures Scotland, as well as individual initiatives with Edinburgh, Glasgow and Strathclyde Universities. Scottish Enterprise also established and funds the three ITIs.

4. **Venture capital.** The Scottish Co-investment Fund (SCF) is a £45 million equity investment fund set up by Scottish Enterprise, and part funded by the European Regional Development Fund (ERDF), to invest from £10,000 to £500,000 in company finance deals between the sizes of £20,000 and £2 million. The fund invests only in partnership with private sector investors.

### 7.3.2 Evaluation of the Role of Scottish Enterprise

Interviews with various actors in the SIS emphasised the pivotal role played by Scottish Enterprise in the governance and development of the SIS. In part, this relates to the range of activities and functions which Scottish Enterprise performs, and in part to the scale and pervasiveness of the influence of the organisation. Actor’s views were less uniform in terms of whether the extent and influence of Scottish Enterprise were positive. Among firms in particular (Chapter 5) our interviews suggest a balance of views, with some firms emphasising the positive role of the LECs and others being more critical of Scottish Enterprise national and its activities.

Interviews with senior innovation and competitiveness executives in Scottish Enterprise emphasised the rationale for improving innovation as part of the agency’s broader competitiveness agenda. A key issue which arose in these discussions – and which is echoed earlier in this report – was the perception that Scotland’s SME sector is insufficiently collaborative, both with enterprise support organisations and with each other. Accordingly Scottish Enterprise looks closely at the most competitive 10% of its approximately 150,000 firms which it is willing and interested sufficiently to support. This is a not an unreasonable posture given the impossibility of serving all firms, and the perceived weakness of many of Scotland’s SMEs.

There was also a perception that the Scottish capital investment market is small and otherwise inadequate for meeting expansionary needs. This was seen as creating pressure for Scottish Enterprise to re-establish new forms of enterprise investment funding despite having privatised its in-house venture capital fund nearly five years ago. This had led to the successful ‘Co-investment Fund’ with the Scottish business angel community.

Scottish Enterprise plays – and is likely to continue to play - a key co-ordinating role within the SIS. Indeed, the broad scope of Scottish Enterprise’s activities and
influence within the SIS put the agency in a unique position to achieve this role. There is a clear need, however, for policy to adopt a systemic perspective with intervention being shaped in relation to its system impact rather than as a response to specific market failures. In other words, Scottish Enterprise is perhaps uniquely placed within Scotland to adopt a role focussing on the management and integration of the SIS. The OECD (1999) study referred to earlier, for example, stresses the importance of this role in ensuring the effective function of the innovation system. Hence, in the view of the OECD, agencies should ‘address systemic failures that block the functioning of innovation systems, hinder the flow of knowledge and technology and, consequently, reduce the overall efficiency of R&D efforts. Such systemic failures can emerge from mismatches between the different components of an innovation system, such as conflicting incentives for market and non-market institutions (e.g. enterprises and the public research sector), or from institutional rigidities based on narrow specialisation, asymmetric information and communication gaps, and lack of networking or mobility of personnel’[^21].

For example, it is possible to envisage a situation in which the effectiveness of the ITIs within their fields of operation may either be constrained by a lack of specific skills, investment or entrepreneurial talent. Or, a situation may arise where highly effective ITIs which stimulate activity within their own sector might exacerbate skill or financial shortages in other sectors. In either case a systemic perspective would highlight such effects, avoiding potential system failures.

### 7.4 Highlands and Islands Enterprise

#### 7.4.1 Role of Highlands and Islands Enterprise

Highlands and Islands Enterprise operates in parallel to Scottish Enterprise with a specific geographical focus on the Highlands and Islands region. Our discussions with the agency, and other actors in the region, emphasised the particular development challenges of the Highlands and Islands region linked to peripherality as well as low business density.

HIE was originally established around 40 years ago to address the specific problems faced by the economy of the Highlands and Island. More recently the agency has sought to change its focus, and the aim is now to create new opportunities in the local economy with a specific focus on stimulating knowledge intensive business activity. HIE have an annual budget around a fifth that of Scottish Enterprise and like Scottish Enterprise operate primarily though the LECs.

Our discussions with HIE emphasised the priority being put on the development of knowledge generation and diffusion capacity in the region – a key focus being the University of the Highlands and Islands (UHI) – and cluster building (e.g. the Inverness medical cluster). Both priorities are intended to overcome the region’s lack of current university level research infrastructure and institutions and strengthen firms’ innovative capacity. Both are also intended to develop the specific competencies and capabilities present in the region. The UHI, for example, has since 1999 been developed as a teaching institution, but developments in research capability

are planned based around marine ecology and the SAMS research centre in Oban as well as nuclear decommissioning.

Other key issues faced by firms operating in the Highlands and Islands region, and emphasised by our informants, are:

- The absence of a university presence limits the possibility for direct knowledge sharing but also reduces firms’ access to such schemes as KTP. This deficiency has, in part, been addressed by the College-Business partnership scheme.

- Agglomeration advantages are also missing from the region due to the low density of population outside the Inverness area. A key response has been the development of broadband networks throughout the Highlands and Islands region to facilitate the development of virtual networks.

- Other barriers to connectivity are: the preponderance of small firms, sectoral concentration in traditional sectors, and a lack of graduate managers. The Fusion scheme – which facilitates networking between firms – is one HIE measure designed to increase connectivity.

Statistical evidence is lacking but anecdotal evidence also suggests that the Highlands and Islands area is marked by a particularly low level of R&D and innovation activity.

7.4.2 Evaluation of the Role of HIE

HIE and its LECs face substantial challenges in trying to promote innovation and technological development among firms in the Highlands and Islands region. While some firms are highly innovative and have strong links to universities in Scotland and elsewhere, there is a consensus that the number of such companies in the H&I region is small. The preponderance of firms tend instead to be small and concentrated in either service industries or mature manufacturing sectors.

Outside the Inverness medical cluster, and public research institutes, there is also a consensus that knowledge generation capacity within the region is very limited. This limits the potential for spin-out creation as well as local knowledge spillovers.

Our discussions with HIE emphasised a response focussing on business development rather than start-up, accompanied by support for the development of the UHI. The latter is clearly a long-term strategy which depends crucially on attracting high calibre research staff to the region, and retaining existing staff members. The development of UHI from the ground-up, however, also offers a unique opportunity for the Highlands region to develop a university whose research activities are more directly linked to the needs of local firms than that of the more established Scottish universities. This may eventually lead to stronger local synergies and spillovers.

To date the impact of the UHI initiative on business innovation in the Highlands and Islands region has been minimal, although other initiatives such as Fusion are better developed. As a result, many firms in the HIE region remain marginalised rather than embraced within the SIS, with a potentially negative impact on their long-term competitiveness. This is, and will clearly remain, a central concern for HIE.
Section 8 - Final Remarks

8.1 Introduction

In this section we make some final remarks relating to the ‘systemic’ nature of innovation in Scotland, as well as system strengths and weaknesses. Key policy challenges are highlighted as part of the discussion of system limitations.

8.2 Is there a Scottish Innovation System?

Section 2 identified three necessary conditions for the existence of an innovation system: coherence, unified function, and boundedness. Within limits, the SIS can be said to exhibit all three characteristics.

Coherence
There is evidence of an array of organisations with common development trajectories, feedback loops and complementary competences between agents. This is most evident in the activities of the Scottish Executive and Scottish Enterprise, and the attempts which have been made to develop institutions which link the knowledge generation and knowledge exploiting elements of the system e.g. ITIs. There are, however, limits to the degree of coherence, notably in the lack of connection between the HEIs and research institutes and the indigenous SME sector. This leads to a sense of ‘imbalance’ within the system, and a need for some agenda re-alignment if greater coherence is to be achieved.

Unified Function
The extent to which there are identifiable aims and objectives to which all parts of the system contribute is mixed. Clearly policy documents such as A Smart Successful Scotland and A Science Strategy for Scotland provide, for the first time, a set of objectives for the SIS and beyond. It is less clear, however, that all parts of the system recognise and accept all these objectives. Again we feel here that a more integrated governance structure – between industrial development and higher education funding – might be helpful. This is discussed in more detail below.

Bounded
Although the SIS is less evidently bounded than, say, that of the UK as a whole, it clearly is possible to determine geographical, institutional and to some extent sectoral boundaries of the system. However, the boundaries of the SIS are probably narrower than those of Scotland as a country; for example, it is clear that there are geographical areas of Scotland, notably the Highlands and Islands and perhaps the Borders and Dumfries & Galloway, which are effectively excluded from the system. It is also important to recognise that the ‘unboundedness’ or openness of the SIS is also part of its strength, with many HEIs and larger firms part of strong international networks.
Having decided that the SIS does indeed exhibit the characteristics of an innovation system, the next stage is to identify the strengths and weaknesses of the system. We discuss this in two sections related to system strengths and weaknesses.

**8.3 Strengths of the SIS**

We see clear strengths in the system. The knowledge generation capacity of the system is high with some key areas of strength. The commercialisation activities of the universities are effective and we see no evidence of any unwillingness to explore alternative avenues for commercialisation on the part of the universities. Scotland’s record on spin-outs and commercialisation is well up to par.

In our discussions the universities saw their mission as very clear – to be internationally recognised centres for research. This was generally seen to have little in common with any very direct mission to contribute to the Scottish economy. Where such positive contributions arose naturally the universities were willing to engage in commercialisation, but different – non-economic – agendas were shaping university strategy and investment decisions. Essentially similar comments could be made relating to the research institutes.

System governance is complex given the region-state status of Scotland and the need to try and ensure consistency between local policy actions and those of national and supra-national actors. During our contacts views varied markedly on the robustness and effectiveness of the current system with widely varying opinions about the impact of Scottish Enterprise’s dominance of the policy agenda. Some viewed this as a system strength – others as blocking innovation and change within the system. What is clear is that there is a general recognition of the centrality and importance of Scottish Enterprise.

Policy innovation within the system is relatively strong. For example, the ITIs represent a major policy initiative both in terms of investment and prestige and although it is early days show some promise of making an effective contribution. They may also play a useful ‘flagship’ role, championing innovation within the Scottish system.

We have not been able to consider this in great detail, but in general terms R&D support measures within the SIS are fairly comprehensive with the LECs having considerable autonomy – and using it – in support of local firms. Some confusion was evident over the number of different support measures available. LECs felt a key role was helping firms to identify the appropriate support measure. We feel there is too little emphasis in the support regime on encouraging partnership between firms and, despite SCORE and SEEKIT, on encouraging university-company interaction.

**8.4 Weaknesses of the SIS**

The pattern of R&D spending in the SIS is well known, with very low levels of R&D in firms and particularly in the majority of indigenously owned firms. This is clearly a weakness of the system and limits both the capacity of firms to develop their own knowledge bases and innovation but also no doubt hinders their ability to absorb external knowledge. This issue is exacerbated by what we feel are low levels of innovation networking between firms and between locally-owned firms and the
universities. Indeed, there is evidence of an almost complete mismatch between the output of the research active HEIs and the absorptive capacity of SMEs, and between the requirements of SMEs and the ability or willingness of HEIs to help.

Differences in the level of investment in R&D and innovation between knowledge generating and knowledge exploiting organisations within the SIS lead to a sense of ‘imbalance’ – with a university sector reminiscent of a ‘core’ EU region and a corporate sector in keeping with Scotland’s more ‘peripheral’ location. Differences in organisational agendas also lead to something of a disconnect between the university and (indigenous) corporate sectors.

The result is a lack of university-industry links and a mismatch between the type of knowledge being generated and demanded. Issues therefore arise on both sides. For the universities there is an issue in terms of more closely attuning their activities to the needs of the Scottish economy. For firms there is an issue of the priority they give to R&D and innovation investment, to upgrade their absorptive capacity and adopt a more ‘open’ stance to innovation links.

In terms of the HEIs, we feel it may be desirable to change the funding incentives to encourage agendas which more closely reflect the needs of the Scottish economy while preserving research excellence. This might include measures to encourage more applied research, and also to strengthen the emphasis on subject areas which can benefit local firms. A positive role model here is the Finnish organisation TEKES which combines the roles of research council and industrial development agency, providing substantial funding for collaborative research activity between HIEs and companies. It is also likely to be necessary to re-focus support for innovation at project level on collaborative or co-operative projects. SCORE, SEEKIT, and SHEFCs’ Knowledge Transfer funding are a start in this area.

Geographical factors, and the location of higher education institutions, create a profound distinction between the situation of firms in the Central Belt and Tayside/Grampian regions of Scotland and companies in the Highlands and Islands and other rural areas. Proximity to universities and the potential for interaction differ markedly – to the extent that firms in the Highlands and Islands, Borders, and Dumfries and Galloway are in many ways excluded from any positive system dynamic at the moment. A partial exception to this may be firms in the medical cluster in Inverness. In the HIE area this may be at least partly addressed by the development of the UHI Millennium Institute.
Annex 1 - European Innovation Scoreboard –
Regional Indicators and Approach

In this Annex we provide an overview of the indicators and methodology adopted in EU (2003), Technical paper 3 of the 2003, European Innovation Scoreboard. This is based around a series of 13 indicators which are defined in Table A2.1. In addition to these basic indicators a composite indicator is used defined as a weighted average of the other indicators. Data from Annex F of EU (2003) was used in the construction of Figure 2.6

<table>
<thead>
<tr>
<th>Indicator</th>
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<td><strong>1. Human resources</strong></td>
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<tr>
<td>1 Population with tertiary education (% of 25 – 64 years age class)</td>
<td>Labour Force Survey</td>
</tr>
<tr>
<td>2 Participation in life-long learning (% of 25 – 64 years age class)</td>
<td>Labour Force Survey</td>
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<tr>
<td>3 Employment in medium-high and high-tech manufacturing (% of total workforce)</td>
<td>Labour Force Survey</td>
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<tr>
<td>4 Employment in high-tech services (% of total workforce)</td>
<td>Labour Force Survey</td>
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<td><strong>2. Knowledge creation</strong></td>
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<tr>
<td>5 Public R&amp;D expenditures (GERD – BERD) (% of GDP)</td>
<td>R&amp;D statistics</td>
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<tr>
<td>6 Business expenditures on R&amp;D (BERD) (% of GDP)</td>
<td>R&amp;D statistics</td>
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<td>7 EPO high-tech patent applications (per million population)</td>
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<td><strong>3. Transmission and diffusion of knowledge</strong></td>
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<td>9 Share of innovative enterprises (% of all manufacturing enterprises)</td>
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<td>14 Regional Summary index – weighted sum of all other indicators. Weights are 0.5 for each CIS-2 indicator and 1 otherwise</td>
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Source: EU (2003), Annex Table A, p.21
Annex 2 - Verbatim Quotes from Company Interviews

On human resources:

‘Within biosciences, we struggle to find the key individuals - there are plenty of graduates, but not people of greater experience. Attracting the right person at the right price is quite hard (particularly from the South, Oxford etc), there’s a limit to the salaries we can pay, so we have to stress the positives of our location, but this doesn’t work with everyone. There is just not the pool of people moving around system. We get plenty of graduate CVs but these are not often what we are looking for - they might be good graduates but they don’t have basic practical lab skills, which means they can’t get straight on with the job. We also find that graduates (and PhDs) can have unrealistic salary expectations (e.g. a new graduate as a clinician expecting £25k). Similarly a PhD is a professional qualification - i.e. it’s not the be all and end all. I think these expectations are being raised by the universities ....’.

On the problems of small size:

‘We do feel somewhat out on a limb as a small company - it’s very hard to keep your finger on the pulse with regard to what is happening with the technology. Having access to a network of people would be useful – there was an innovation network… but that fell a bit flat. I did feel there that people were a bit reluctant to share their ideas’.

‘Working in industry (in a large firm) I was quite used to bouncing ideas off other people as part of the development process - its hard to do this in our very small firm’.

On the culture of innovation and entrepreneurship

‘At the innovation park where we were - I’m often the only person working here after hours; i.e. I didn’t see that much commitment from a pool of people apparently wanting to grow their businesses and get their ideas out there. Perhaps we are just too comfortable (or lazy?) to take the risks?’

‘There is also a complete lack of innovation culture (e.g. process improvement etc) within the Scottish NHS - this needs to be addressed at a policy level. Its difficult to build your business when your home market isn’t receptive. We are doing more and more business south of the border - partly driven by the fact that its just a bigger market. But; if we end up doing more and more business away from our base, we may have to consider moving south’.

‘SHI [Scottish Health Innovations] are supportive, but they don’t really have any power. People in the NHS are driven by short term goals - making the numbers add up at the end of the year. I can think of a specific project with us that would have saved them money in the long run that they decided not to run. People in the NHS are on a career ladder and won’t stick their neck out to

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avoid “blame” for anything that might “go wrong”- totally risk averse. This is a wider issue for the UK as a whole’.

‘It is too hard to get these ideas out into the market- SHI have been involved but the whole process with them has been bogged down in legal issues- too many constraints’.

On the LECs

‘We have an excellent person in the LEC who is extremely helpful, and they have been very supportive more generally e.g. helping with overseas linkages and so on. There does however seem to a lack of people within SE with a science background- you tend to referred on to someone, who doesn’t understand it either and in turn refers you on somewhere else and so on’.

‘I am a strong supporter of Scottish Enterprise at the point of delivery on the ground- this stuff tends to be very practical and driven by our own needs (for example Small Company Innovation Scheme, training support for staff and so on.) This sort of thing is directly helping our immediate R&D, our innovation, customer support and skills base. Other elements of SE I tend to see as either too far-sighted, too short-sighted, or not practical enough- and not a good use of public money’.

‘The LECs have some good people, but these are not made best use of- sometimes this is down to the LECs themselves, but often the SMEs are reluctant to let anyone in. The people from the LECs really need to know what’s going on at a first hand level, rather than at 2nd hand via the account manager. If you insist on keeping the account manager at arms-length, then it’s not surprising that they don’t understand the business, which is a complaint you often hear’.

‘I think the “lone entrepreneur” image is a barrier- i.e. a number have this ideal (perhaps not even consciously) that 1 guy can do it all- the technology, the finance, the marketing etc. etc. - this makes them very reluctant to let anyone else in, or to collaborate’.

On Scottish Enterprise:

‘What is SE for?- is it start-ups, is it a last resort- what? Its ill-informed advice from people with no experience. I think the start-up fund is a waste of time. It certainly shouldn’t be about the numbers- what counts?- is it one guy with three-pence turnover?- there needs to be some sorting of the wheat from the chaff’.

‘I generally feel that Scottish Enterprise are quite good at kick-starting new companies, and quite good with large ones … but ones like us fall somewhere between the two’.

‘Scottish Enterprise shouldn’t have a ‘social’ role, this has been forced on it by Scot Exec. For example “women into business” – this might well be a ‘good
thing’ but in what way?- economically, socially – what? It’s a compromise, and sends out a confused message’. 

On co-ordination and conflicts:

‘Support tends to be very localised indeed- i.e. there is one body in Ayrshire, one in Renfrewshire and so on- they all seem reluctant to spend money that will generate benefit outside their own LEC area. You get asked questions like why didn’t you get that work done in Ayrshire?, why didn’t you have that analysis done in Ayrshire? Etc. - usually the answer is simply because there was no one who could actually do it. - surely the point should be what is the benefit for Scotland as a whole. We also had a situation which involved collaboration with a company in another LEC area; we each had to apply for money separately. It would have been much more sensible to apply together, and if successful the cash split equally by the two LECs’.

‘I also wonder if there are too many groups- i.e. do all the universities need their own innovation department, and why are there so many LECs? For example people I met in the US were more familiar with the Dundee LECs bio-group than they were with that of Scotland as a whole - i.e. it seems that these bodies are competing internationally against each other’.

‘To some degree the aims of the Proof of Concept fund and SMART contradict – with the PoC you are not allowed to actually form a company – it is for taking a technology up to this stage – conversely SMART has to be within a commercial company – i.e. can’t be used a substitute funding for academic research – i.e. there is some lack of flexibility between the two’.

On connectivity to HEIs:

‘We are in theory in an incubator unit, but it’s poorly run as one, and we weren’t even aware of these units (in the Uni.) when we started – not publicised. Most companies here aren't actually spin-outs; the units are rented out a reasonable rate to fill them and generate some cash’. 

‘Where we are located- although it’s called a science park, its really just an industrial park- i.e. there is no real clustering effect. This is partly due to the infrastructure and partly due to the other companies on site- i.e. it’s a bit of a random collection, probably driven by the need to rent the units. So we pay extra for being on a science park without really seeing any added value- which is why we are looking to move’.

‘For example the ITIs- I don’t feel that these have been particularly valuable. Linked to cluster policy- ITIs are supposed to be involved in this, but my view is that effective clustering only happens when there is a large organisation at the centre- i.e. one driving business with the others growing around it. What Scotland lacks is large growing organisations that are able to be the cluster leader, that have the scale and capacity to lead innovation in a global market- and this isn’t something that the ITIs can really do’.
‘We can tend to obsess with technology transfer directly from the Universities at the expense of other strategies- clustering for example’.

On supporting spin-outs and start-ups:

‘I generally feel that Scottish Enterprise are quite good at kick-starting new companies, and quite good with large ones … but ones like us fall somewhere between the two’.

‘I think scientists need to be able to go to SE and get their ideas protected, and then SE could go out to business with these- at the moment this doesn’t happen, its all left to pot luck. In our case, I have the experience of being finance director for a large company, and my colleague has the science background- so between us we have a good idea of where we’re going. We find it hard enough- many people don’t have this combination and must find almost impossible’.

‘I don’t see the spin-out thing being promoted that well – either by SHI, or from the universities. If the ideas etc that were there were showcased effectively, business people would be able to commercialise them. You need to match the tech expertise with the business experience. Getting things to market is the key issue- linking ideas to entrepreneurs in existing companies- spin-outs aren’t always the best way to do it. Most of the costs for a start-up go towards infrastructure- why do these each time?’

‘Scottish Enterprise and the people in the Universities- very few of these have actually had ‘real-life’ experience of setting up a business- they can have all the specific skills, but lack this knowledge’.

‘The guys with the ideas often have no business experience, many would have benefited from having this experience earlier in the process; for example in terms of the attitudes they have towards giving up control of certain parts of the business (i.e. to investors etc). The LECs find it quite easy to point companies in the direction of specific expertise- lawyers or finance or whatever, but you really need a pool of grey-haired business people who can offer their expertise’.

‘Sales and marketing is a big problem- i.e. the people who have developed the technology sometimes wonder why their product isn’t selling. Most of these products tend to be quite sophisticated- very few will actually sell themselves. The problem in Scotland is that the people with this level of sales experience often move south of the border, and/or are more interested in joining a large company than a new one’.

‘IP barrier- people are apprehensive about letting business people get hold of their ideas- untrusting of business. People who are inventing things aren’t business people- they usually aren’t interested in how business works, and are utterly surprised when someone gives them some money- scientists often just don’t expect to get any money for what they enjoy doing’.
'There are lots of scientists who think they have a good idea. Pure scientists often get bogged down in the detail of their research, i.e. the exact reasons for why a certain effect takes place etc, rather than just that it actually works- this is of course partly because this is what is needed for papers etc’.

‘There are plenty of ideas coming out of the universities etc- sometimes the commercialisation processes work, sometimes they don’t. Often the academic people are unwilling to let go of an idea and so do their own spin-out, and this often fails because the business basics are not in place- this is where the help is needed. Also, the overheads imposed by the universities can scupper a lot of deals’.
References


