



Scotland's Commercialisation And Research Asset Base (SCARAB)

Scottish Enterprise

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Executive Summary

Background

The Scottish Government Economic Strategy (GES) highlights that Scotland needs to make better use of its assets to develop a clearer competitive edge, and develop competitive advantage in its industries and sectors. This calls for effectiveness of national policy and spending, strengthening links between Scotland's research asset base and business innovation, and increasing business expenditure upon research and development.

Policy now directs effort toward sectors that have high growth potential and the capacity to boost productivity. GES identifies a number of national priority industry sectors: Creative Industries, Energy, Financial and Business Services, Food and Drink; Life Sciences; and Tourism. Future Scottish Enterprise (SE) activity will emphasise support for investment and innovation by these industries and sectors that are deemed to have the greatest growth potential. Commercialisation from HEIs is an important contributor to deepening and widening innovation within those sectors and fuelling growth.

Study Approach

DTZ was commissioned by SE to undertake a mapping study of Scotland's Commercialisation and Research Asset Base (SCARAB). The study focuses on the research activity 'hot-spots' in Scotland, especially where research has potential for commercialisation and helps to raise the rate of economic growth in Scotland. In doing so, the study will help SE to target support for key areas of research in Scotland that support Priority Industries and commercialisation of research.

The study has involved three streams of research: a literature review of published reports, relevant data and SE and Scottish Government policy documents, such as the GES; secondary data analysis and evaluation in respect of research activity and quality; and consultation with commercialisation managers, SE University Relationship Managers; Scottish Development International; and Directors of the SE Priority Industry Teams.

Research Findings

Scotland's universities deliver world class research well beyond the volumes expected for a small country, and yet business R&D lags most comparator developed economies¹. Nearly 9,000 staff are actively involved in nearly £600 million of HEI research each year with just over £33 million funded from commercial sources.

Today, Scotland's top research Universities remain its 'ancients', i.e. Edinburgh (£166 million in 2005/06 income), Glasgow (£111 million), Aberdeen (£56 million), and St Andrews (£41 million), or those arising from the civic university era such as Dundee (£58 million) and Strathclyde (£46 million). This has resulted in a concentration of research activity in historic locations, such as St Andrews, and/or urban areas.

¹ Roper et al, 2006

Of the top ten research HEIs in terms of income, six are located in the East of Scotland along with £334 million (58%) of all research income, 63% (or £346 million) of R&D in business was also located in the East of Scotland, and an estimated 68% of the £105 million of funding for Government research institutes, such as the Roslin Institute and Rowett Institute, which are now part of the Universities of Edinburgh and Aberdeen, respectively. The West of Scotland absorbed £169 million in HEI research income in 2005/06, while Aberdeen City and Shire drew in £61 million.

By contrast, the South of Scotland (estimated to be <£1.0 million) and the Highlands and Islands (<£10 million) fare badly from investment in HEI research and this is compounded by low business and Government spend on R&D. It may be unrealistic to see these weaker regions match spend on R&D in the East of Scotland, even in the long-term, but policy may need to reflect upon such disparities, and seek to promote a degree of convergence, if HEIs and their impacts on economic development are explicitly recognised.

Scottish Enterprise, Scottish Funding Council or the Scottish Government, should not attempt to dictate to Universities where research is located, but could explore incentives to locate research in weaker regions with low GVA, where this is sensible to do so. While locally located HE research can act as a driver for inward investment, where this is not feasible or practical, these weaker regional economies could also be strengthened by providing greater encouragement of linkages between local employers and relevant research active HE elsewhere in Scotland.

By 2005/06, Scotland's academic research base had become highly geared towards delivery of research within subject areas related to Life Sciences and Energy. Life Sciences accounted for just over half of all annual research grants and contracts income (54%) for Scottish universities, or around £210 million. A total of £98 million in research grants and contracts income was of relevance to the Energy sector in the same year, or 25% of the total for Scotland. Other significant areas of academic research capability are in relation to Digital Markets and Enabling Technologies, Aerospace, Shipbuilding & Marine and Chemical Sciences.

In practice there are significant areas of overlap in academic capabilities between all these key disciplines, with areas such as Physics and Chemistry providing an enabling role for many priority industries. Other core research disciplines include clinical medicine, biological sciences, electronic engineering, mechanical engineering, informatics and mathematics. All are key to Scotland's performance in supporting priority industries and research consortia. Scotland has some cutting edge academic consortia across a wide range of research areas, including SUPERGEN in energy, the Scottish Universities Life Sciences Alliance (SULSA), and ScotCHEM for Chemical Sciences.

However, a feature of Scotland's economy is its dominance by priority industries with a low propensity to generate or demand R&D, such as tourism, food and drink and financial services, which collectively employ 440,000 workers in Scotland². Just £12.8 million was dedicated to R&D in areas of potential relevance to financial services, while tourism attracted less than £0.1 million in income and food and drink attracted around £8 million.

² Source: Scottish Enterprise Priority Industry Statements.

Scotland's HEIs are slightly better than UK comparators at drawing down income from UK industry, commerce and public corporations, particularly among post-1992 universities. If pre-1992 universities had a similar propensity to attract funding from UK industry or commercial sources as their post-1992 counterparts, then total UK sourced funding of this type in Scotland would almost double. At present, when combined, all of Scotland's pre-1992 institutions failed to draw down as much funding as did Imperial College, in 2005/06.

Scotland's academia has extensive collaborative partnerships with academic and commercial partners from around the World. This is necessary to provide the economies of scale to undertake quality research and to viably exploit its outputs.

In relation to some priority industry research, it is clear that not all research could reasonably be absorbed or commercially exploited by businesses in Scotland, e.g. our life sciences sector possibly does not have a sufficiently large production base to exploit all Scottish research. However, it does have a regulatory competitive advantage and close links with health trusts and academia that attract investment in R&D from abroad, e.g. Wyeth's investment in translational medicine.

Questions have been raised over the rationale for investment in research where intellectual property cannot currently be exploited in Scotland. In our view, Scotland may benefit through:

- generating and re-investing licensing income from intellectual property rights, although it must be recognised that not all such research is successfully commercialised;
- reputational benefits for perceptions of Scotland as a location for investment and ideas;
- diseases do not respect boundaries, i.e. Scottish patients can benefit from medical breakthroughs, even if manufacturing of products is elsewhere;
- exporting knowledge can allow Scotland, as a small nation, to contribute to alleviating global challenges that threaten us all, such as pandemics or climate change; and
- attracting match funding from other commercial, governmental or charitable sources and, potentially, attracting foreign direct investment to exploit research here.

By contrast, energy stands out as an area where university research, commercial activity and job creation potential are all well-aligned, due to the presence of an established base of larger energy companies, as well as considerable natural resources in oil, gas and renewable energy. Scotland's energy-related academic base is well placed to help exploit the twin challenges of a looming global energy crisis and the threat of climate change and is attracting international partners. Scotland can and must ensure that it grasps this opportunity before the technology is exploited elsewhere.

The scale and scope of SE support for commercialisation of research is considerable and there is a clear strategic commitment to commercialisation. Significant sums have been devoted to a range of programmes, including: Intermediary Technology Institutes, for key priority sectors such as Energy; Proof of Concept funding, as set out in more detail throughout this report; establishment of Enterprise Fellows; support for the Translational Medicine Research Collaboration, involving companies such as Wyeth; and wider entrepreneurship and commercialisation initiatives.



Priority Industry streams, most notably in areas such as Life Sciences and Energy, have well-developed knowledge of key academics within their sectors. Notwithstanding the potential for extension of the dataset, the database developed by SE's Energy team is an exemplar.

The pioneering 'Edinburgh-Stanford Link' project is a significant development that will not only facilitate specific academic collaborations, but also bring about a cultural and knowledge transfer from one of the World's most successful universities in terms of commercialisation into Scotland's largest research-led university, Edinburgh. The direct impact of this project may take a while to take effect, but hopes are high that medium to long term benefits will accrue.

Moreover, following reorganisation, SE is developing dedicated regional commercialisation teams, and this further demonstrates the refocused SE's commitment to developing a more effective interface between academia and all of Scotland's priority industries, and to achieve progress across all regions within the SE area.

1. Introduction

1.1 Study Aim

DTZ was commissioned by Scottish Enterprise (SE) to undertake a mapping study of Scotland's Commercialisation and Research Asset Base (SCARAB). This study focuses on the research activity 'hot-spots' in Scotland, and specifically upon those aspects of research that have the greatest potential for commercialisation and, through this, the greatest potential to aid growth and development of the SE Priority Industries and to raise the rate of economic growth in Scotland.

This study will help Scottish Enterprise in targeting support for key areas of research in Scotland. The evidence and analysis will provide the Priority Industry and Commercialisation teams of Scottish Enterprise with a clear overview of the current research asset base in Scotland. This provides a baseline for monitoring development of Scotland's commercialisation and research base in future years and helps to steer and target future activity carried out by the proposed commercialisation teams within the new regional structure for SE.

Research and commercialisation activities are crucial to the successful development of SE priority sectors and for the implementation of Scottish Government economic strategy. We therefore understand the imperative for identification of those research areas that would both benefit from future SE activity and that would yield the greatest economic returns for any investment, in terms of research and innovation, knowledge transfer and industry benefits.

A key area of the research will be to set out the extent to which the research base currently meets or may potentially meet the emerging needs of the priority industries. The Priority Industries, as defined by SE, are: **tourism; food and drink; financial services; life sciences; energy; digital markets and enabling technologies; textiles; aerospace, defence and marine; chemical sciences; construction; and forest industries.**

A further objective of this research is to provide an analysis of the strategic fit of the activity "hot spots" in relation to the SE defined priority industries strategies, the SE Innovation and Commercialisation strategy and Scottish Government targets and strategic objectives, paying particular attention to the recently published Scottish Government Economic Strategy (GES). The report will subsequently inform SE how to more efficiently target and harmonize research areas and priority industries in Scotland. This process will highlight areas of opportunities whereby further activity and investment will enhance the strength of the sector.

We identified some areas where there is further scope for development, and where current opportunities are not met and/or realised. Higher Education is a critical contributor to the growth of high value added and knowledge intensive industries, and is subsequently a key driver of economic growth.

The study sets out to not only evaluate the research capacity of the academic infrastructure in Scotland, but also any collaborative links (university-to-university and university-to-industry), improved links with industries, knowledge transfer potential and, where it is evident, market failure on the part of the academic community in meeting the needs of particular priority sectors/industries.

It will also potentially help the sector to establish a much greater visibility within the policy and business community for its role in underpinning leading-edge and core areas of Scotland's economy in support of new, emerging companies and in providing entrepreneurial support and support in product development to the Scottish economy. The information collated will help Scotland to compete on a global stage, help to sell Scotland to international research collaborators and facilitate international inward investment interest.

1.2 Our Approach

1.2.1 Stage One – Literature Review

The literature review consists of secondary desk research of published reports, information and data about research activities and performance of universities in Scotland. This research assists the mapping of the current academic research asset base, investigating issues of:

- Academic research strengths, resourcing and performance;
- University competitiveness in research disciplines, paying particular attention to areas where there is felt to be greatest potential for economic growth; and
- Domestic and international research collaboration and pooling involving academic personnel.

Secondary data is sourced regarding recognised research activity, through the Research Assessment Exercise (RAE) and a review of institutional websites to investigate research centres that are new or where not submitted for the 2001 exercise or, indeed, for the 2008 study. This is supplemented with data from the Higher Education Statistics Agency (HESA), for the 2005/06 session, on research income (by source), expenditure, research active staff numbers, support staff numbers, and student numbers (i.e. postgraduate research). Citation statistics were also used to assess the international significance of research undertaken by institutions.

A review of the strategic documents available sets the scene for economic development strategies adopted by the SE and the Scottish Government. These are:

- Industry Demand Statements for each of Scotland's priority industries;
- SE Innovation and Commercialisation Strategy; and
- Government Economic Strategy.

1.2.2 Stage Two – Consultations with Key Stakeholders/Partners

We have conducted semi-structured interviews with a number of senior management staff of the universities in Scotland; with the SE University Relationship Managers; and with the Directors of the SE Priority Industry Teams to identify key research hotspots and priority industries' demand for research.

1.2.3 Stage Three – Analysis and Evaluation

Our analysis focuses on providing stakeholders within Scottish Enterprise and academia with reliable and relevant evidence to encourage partnerships and programmes stimulating economic development. Our report therefore shows some specific opportunities but is broad enough to engage stakeholders from a wide range of backgrounds.

1.2.4 Stage Four – Reporting

Our analysis is focused on providing stakeholders within Scottish Enterprise with reliable and relevant evidence to encourage partnerships stimulating economic development. The three overarching aims are:

1. Identify baseline picture with research 'hot-spots';
2. Merge with updated Metro West research; and
3. Analysis of commercialisation and strategic fit.

This evidence and analysis provides the Priority Industries and Commercialisation teams of SE with a clear overview of the current research asset base in Scotland. The focus is on commercialisation and the study supplies a basis for further activity carried out by SE and its stakeholders.

2. Background

2.1 Policy Background

The policy context, as set out in the Scottish Government Economic Strategy, Scottish Enterprise Innovation and Commercialisation Policy and Priority Industry Demand Statements, re-emphasise the purpose and focus of government activity and identifies the following key issues:

- Align investment in learning and skills with other key priorities;
- Supportive business environment through a business demand led strategy;
- Strengthening the link between Scotland's research asset base and business innovation;
- Focus on delivery and outputs; and
- Clearer line of sight to the market.

2.1.1 The Scottish Government Economic Strategy

The Scottish Government's economic strategy was launched on 13 November 2007. The strategy identifies the need for a new sense of purpose nationally and a clear focus on the delivery of the purpose, which ultimately has implications for SE. The central purpose is:

'... to focus the Government and public services on creating a more successful country ... through increasing sustainable economic growth'.

The focus is to align investment in learning and skills with other key priorities and in doing so creating a supportive business environment and react to the demands of business. Scotland needs to make better use of its assets to develop more of a competitive edge in order to achieve stronger comparative advantage in its industries and sectors. In addition to the alignment of policy and resources, it will be combined with a greater emphasis on the effectiveness of national policy and spending.

To create a supportive business environment, there will be a clear focus on strengthening the link between Scotland's research asset base and business innovation, and to address low levels of industry research and development. Policy shall focus on key sectors and areas that have high growth potential and the capacity to boost productivity. Sharper aspirations are adopted with national targets, which include specific benchmarks for economic growth.

The key sectors, as identified by Scottish Government, differ somewhat to the Priority Industries of SE. The sectors identified as potential areas of strong competitiveness and growth are:

- Creative Industries (including digital content and technologies);
- Energy (with a particular focus on renewables);
- Financial and Business Services
- Food and Drink (including agriculture and fisheries);
- Life Sciences (including biotechnology and translational medicine); and
- Tourism.

These sectors will be supported by technologies that contribute to further development, and on this basis another area could be considered as a key sector:

- Enabling Technologies.

Enhancing the quality and focus of support to industry and for innovation has the potential to have a positive impact on national competitiveness and economic growth. The derived assumption is the SE activity should be focused on supporting investment and innovation by industries and sectors that have commercial benefits and growth potential.

2.1.2 SE Innovation and Commercialisation Policy

Reflecting the priority given to Innovation and Commercialisation in the Government's new economic strategy, a new policy paper from SE set out their policies towards providing a sharper focus to SE's work in this area. There is a renewed importance of Innovation in SE driven by principles of stronger focus on business and the deepening and widening of business innovation or diffusion.

Commercialisation from Higher Education Institutes (HEIs) is an important contributor to this process. Furthermore, there is a stronger focus on outputs and consolidation with a clearer line of sight to the market and an emphasis on company building. SE will have a role in the following processes that stimulate commercialisation of innovation and research:

- R&D support;
- Collaboration; and
- Knowledge transfer.

The policy also recognises the need to improve the overall environment for Innovation, including addressing the needs and demands of the Priority Industries.

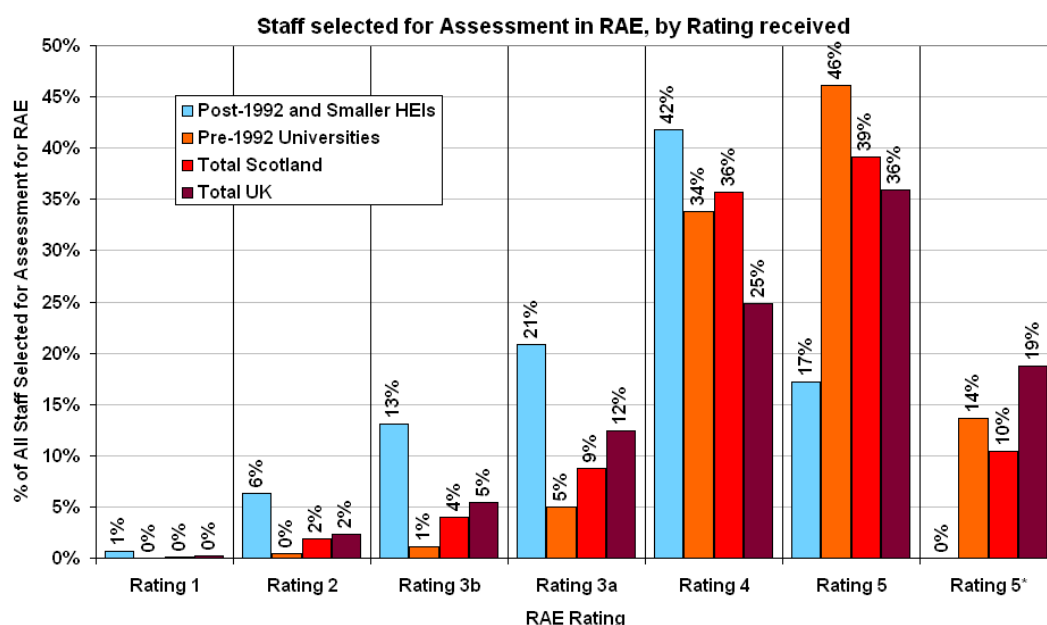
2.2 Historic Performance and Visibility

Scotland has historically performed well in research, with just over 5,800 academics assessed in the 2001 Research Assessment Exercise (RAE). Additionally nearly 3,600 further staff were actively involved in research across Scotland but were not included in the 2001 RAE. In the 2001 RAE 85% of academics were rated at 4, 5 or 5* in quality, compared with 79% for the UK as a whole.

At a UK level, a greater proportion (55%) were rated either 5 or 5*, indicating research of truly international standing, compared with 49% in Scotland. Scotland's pre-1992 universities performed particularly well, with 94% of staff submitted for assessment being awarded a 4 rating or better, and 60% received a 5 rating or better, but they under performed in relation to generating 5* rated departments, with just 14% of staff attaining this rating (19% for UK).

Perhaps unsurprisingly, Scotland's newer universities did not fare as well, as they were starting from a lower research base. However, 59% of staff were rated as 4 or better, although none achieved the much coveted 5* status at that time.

Figure 2.1: RAE Research Active Staff Profile

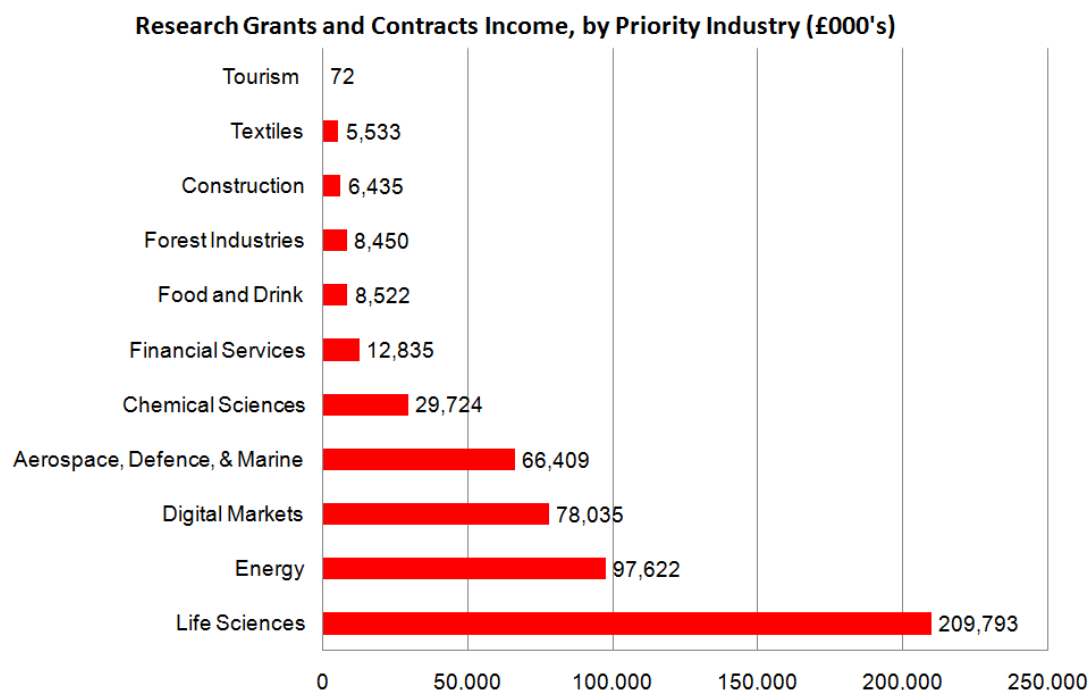


Source: Research Assessment Exercise 2001; adapted by DTZ

This study has identified that Scotland's academic research base is highly geared towards delivery of research within subject areas related to Life Sciences and Energy, as shown below. Other significant areas of academic research capability are in relation to Digital Markets and Enabling Technologies, Aerospace, Shipbuilding & Marine and Chemical Sciences.

In practice there are significant areas of overlap in academic capabilities between all these key disciplines, with areas such as Physics and Chemistry, in effect constituting areas of research providing and enabling role for many priority industries. Hence the figures shown below are not mutually exclusive, given that there is double counting of key departments in more than one sector and this indicates the significance of identification of the availability of research resources for deployment across industries.

Figure 2.2: Research Grants and Contracts Income, by Priority Industry



Source: HESA (© HESA), HE Finance Plus 2005/06; adapted by DTZ

Scotland has a broadly similar profile in terms of its profile of research income by source, as shown below. However, Scotland's HEIs are slightly better than UK comparators at drawing down income from UK industry, commerce and public corporations, as shown below. However, the comparison between Scotland's pre-1992 universities and the post-1992 universities and smaller HEIs is instructive.

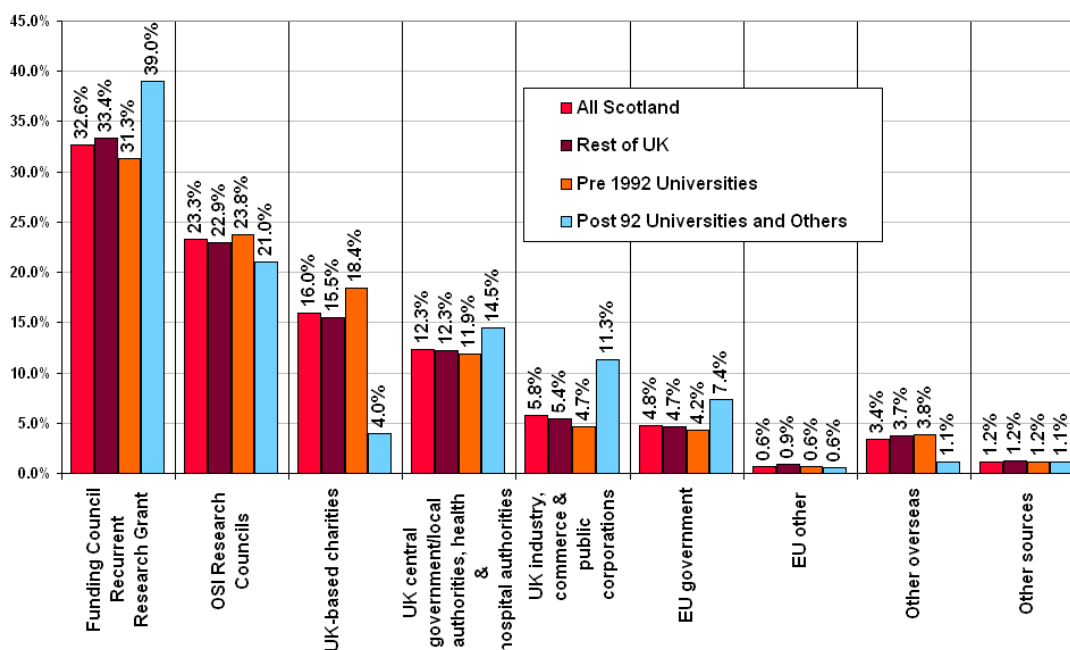
Aside from greater SFC dependency, the Post-1992 institutions are far more engaged with UK commercial funding partners and far less engaged with UK-based charities than are their pre-1992 comparators. It also appears that they are comparatively successful in terms of EU research funding, perhaps including Framework 7 projects. UK charities play a particularly important role in funding pre-1992 universities in Scotland, reflecting the particular strength of Life Sciences research in Scotland.

However, in terms of aggregate commercial income, they are modest players, drawing down just £11.1 million from such funders, in comparison with £22 million taken by the Ancients and other pre-1992 universities.

However, by comparison with UK comparators, even Scotland's most successful institution, University of Edinburgh, is well down the UK league table for attracting commercial income. Combined, all of Scotland's pre-1992 institutions failed to draw down as much funding as did Imperial College, in 2005/06.

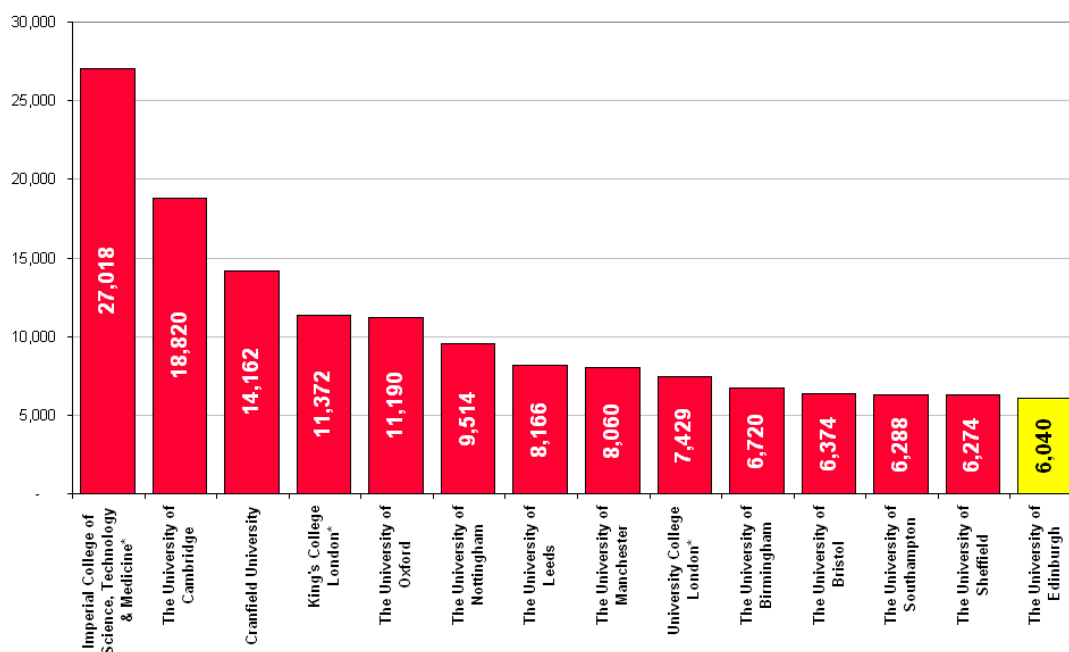
Figure 2.4 shows the University of Edinburgh and UK comparators in terms of Research Income (expressed in £000s) derived from UK industry, commerce & public corporations

Figure 2.3: Profile of Research Income by Source: Scotland and Rest of UK



Source: HESA (© HESA), HE Finance Plus 2005/06; adapted by DTZ

Figure 2.4: Research Income Derived from UK Industry, Commerce and Public Corporations (expressed in £000s)



Source: HESA (© HESA), HE Finance Plus 2005/06; adapted by DTZ

3. Priority Industries

3.1 Life sciences

3.1.1 Overview

The Scottish Life Sciences Strategy outlines a critical mass of companies of scale, anchored long term within Scotland. The strategy's vision includes a globally focused, sustainable life sciences sector built on a fully connected national strategy. In 2005/06, Life Sciences accounted for just over half of all annual research income (54%) for Scottish universities, around £210 million, and stakeholders identified numerous areas of niche, and often complementary, research strengths across institutions. Scotland accounted for 13.1% of all Life Sciences research grants and contracts income within the UK HE sector.

In terms of a global focus, translational medicine and stem cell research were frequently cited as key research areas for Scotland going forward. Stem cell research was identified as a particularly significant opportunity given current legal restrictions on stem cell research in the United States and a limited number of stem cell research clusters including Kobe (Japan) and Stockholm (Sweden).

Stakeholders frequently suggested that individually, Scotland's universities often lack the scale to compete effectively with other global research institutions and regional clusters. Research pooling has been critical to success. A number of collaboration programmes are already underway including the Scottish Universities Life Sciences Alliance³ (SULSA), Translational Medicine Research Collaboration⁴ (TMRC) and the Scottish Institute for Life Sciences (SCILS).

While stakeholders concede that Scotland does not have unique expertise, Scotland's sector is of very high quality. While small, it is nimble and can adapt quickly, e.g. moving quickly to deliver stem cell capability. Interdisciplinary research as it relates to Life Sciences is something Scotland does well and the structure of our NHS is such that it facilitates access to patients.

³SULSA aims to enhance strengths in Cell Biology, Systems Biology and Translational Biology to create a new research structure that will strengthen excellence within and between these themes. Some £77.6M of strategic investment has been made by 6 Scottish Universities in partnership with the Scottish Funding Council (SFC), with this being targeted at developing research leaders, new talent, and state-of-the-art shared facilities and equipment. The six university partners are **Aberdeen Dundee, Edinburgh, Glasgow, St Andrews and Strathclyde**. Further information is available at <http://www.sulsa.ac.uk/>

⁴The TMRC is a unique collaboration involving Scotland and Wyeth, a top ten global pharmaceutical company. The programme involves the establishment of a core Research Laboratory (located at University of Dundee) linking with the four major clinical academic centres at the **Universities of Aberdeen, Dundee, Edinburgh and Glasgow** and the NHS in Scotland, initially working with NHS Grampian, NHS Greater Glasgow, NHS Lothian and NHS Tayside. The collaboration therefore covers over 70% of the Scottish population. More information available at <http://www.tmr.co.uk/>

3.1.2 Key Academic Centres

The universities of Edinburgh, Glasgow, Dundee and Aberdeen were frequently cited as hosting the core of life sciences research with St Andrews University and the University of Strathclyde also playing important roles, with the latter leading development of medical devices. Greater collaboration between the four core universities and international partners was highlighted as important in underpinning global competitiveness.

Scottish institutions also have great strength in oncology-related research. For example, University of Aberdeen and NHS Grampian have an excellent collaborative record in that respect. Edinburgh has a very broad base, but also has strength in oncology, while University of Glasgow is also strong on oncology. Edinburgh's strength is seen as being in the 'basic or blue skies research' while Glasgow has strength in applied research, e.g. through the work of the Tumour Suppression Unit of the Beatson Institute. The University of Dundee, too, has strength in oncology, but also is at the forefront of work in the area of diabetes research.

Scotland's strengths⁵ are in tackling:

- Oncology;
- Diabetes;
- Cardio-vascular illnesses;
- Metabolic research;
- Bone diseases;
- Inflammatory conditions;
- Women's health issues; and
- Conditions affecting the central nervous system.

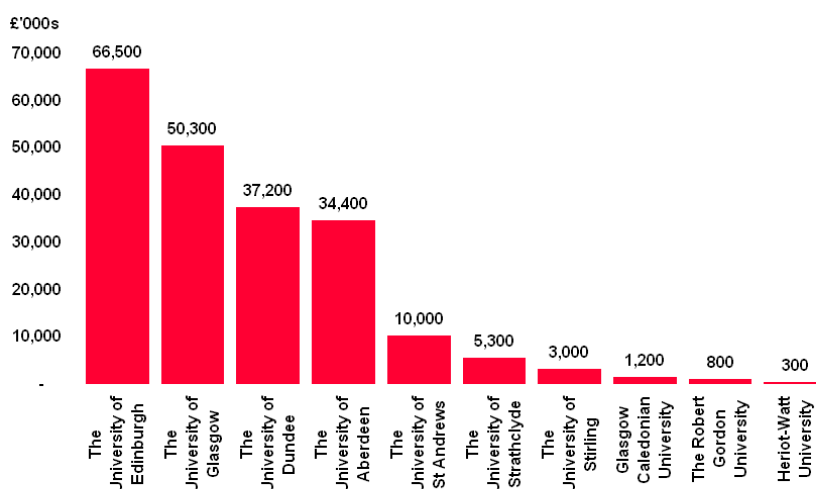
3.1.3 Income and expenditure

Research income

The University of Edinburgh dominates life sciences research grants and contracts income with just over £66.5 million in (2005-06) or 32% of the total for Scotland.

When combined, Edinburgh, Glasgow, Aberdeen and Dundee account for around £188.5 million, or 90% of all life sciences research grants and contracts income.

Figure 3.1: Total Research Grants and Contracts Income



Source: HESA, adapted from original by DTZ

⁵ For a full description of the role played by each of the four partner HEIs in the TMRC, see www.tmrc.co.uk/therapy_areas

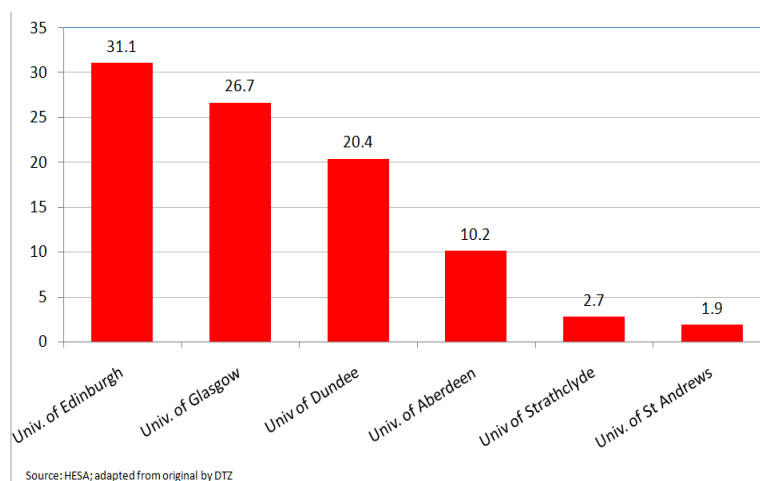
The University of Edinburgh has, in absolute terms, the largest life sciences research income stream, accounting for 59% of all research grants and contracts income for the university. However, the University of Dundee is, in relative terms, the most life sciences focused university in Scotland, with 87% of all research grants and contracts income coming from life sciences.

Commercial research income in Life Sciences

The contribution of the four core universities is starker when considering commercial and UK charities research income. The top four universities account for almost 94% of all commercial or charitable life sciences research income in Scotland.

Dundee (55%), Glasgow (53%) and Strathclyde (52%) all receive more than half of their income from these sources, while Edinburgh is not far behind (47%). Aberdeen (30%) and St Andrews (19%) attract less funding from commerce and charities. Aberdeen has a greater reliance upon health trust funding with 24% coming from this source and 15% from overseas. St Andrews receives 52% of its funding from research council sources.

Figure 3.2: Total Commercial / UK Charities Income (£millions)



3.1.4 Workforce

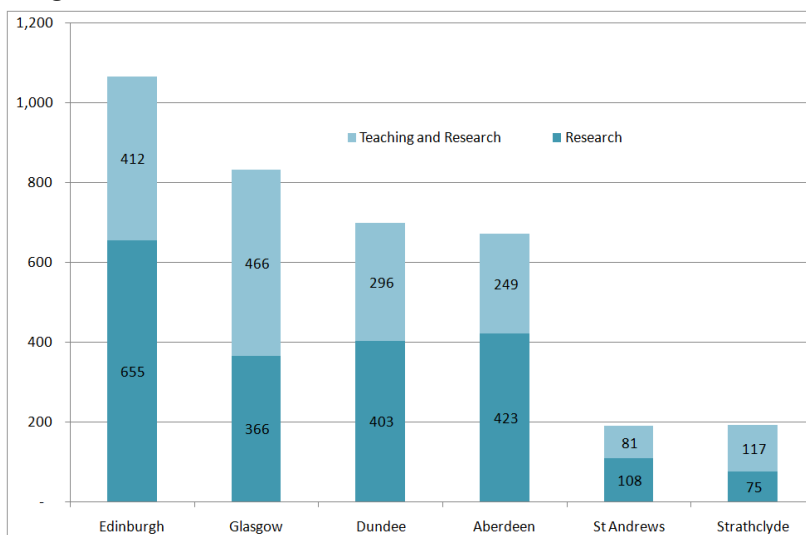
Staff

In 2005/06, some 7,350 staff were employed by Scottish universities in the field of Life Sciences. Of the total, 70% work at the top four Life Sciences universities, i.e. Edinburgh, Glasgow, Dundee and Aberdeen. Life Sciences staff make up 21.6% of all University staff, of all grades, employed in Scotland in 2005/06. Collectively, Life Sciences activity is bigger in scale than the University of Edinburgh (6,360 staff in total) and, in a virtual sense, is large enough to be a university in its own right.

Research staff

Within Scotland, there were nearly 2,160 staff employed exclusively in academic research positions, i.e. 'research only', while a further 2,080 staff in posts combining teaching and research functions. Hence, 4,240 academic professionals were engaged in pursuit of Life Sciences related research to some degree. This accounts for one third (33%) of all Scottish academic professionals working in research. For 'Research Only' staff, Life Sciences accounts for 51% of the total of 4,260 employed in Scotland, while these disciplines employ 24% of staff engaged in both teaching and research.

Figure 3.3: Staff numbers



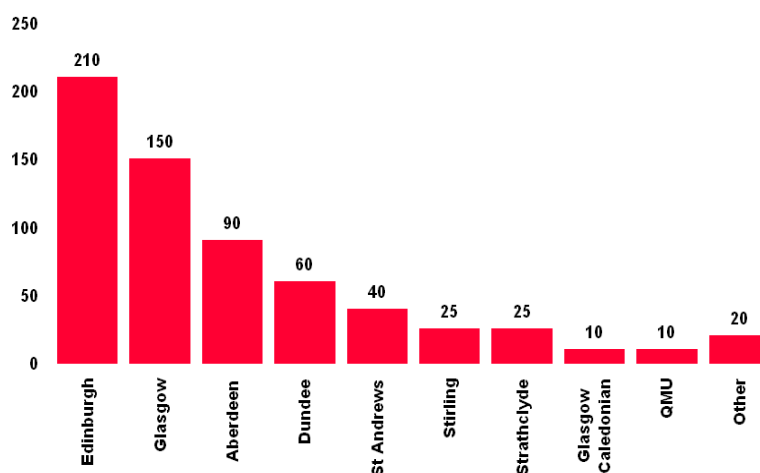
Edinburgh has more staff in dedicated research functions, followed by Aberdeen. Glasgow has a more even balance between staff engaged in teaching and research.

By discipline, Clinical Medicine accounts for 43% (1,565) of all research active academic staff at the top 6 institutions, while Biosciences accounted for 37% (1,335). In addition, 7% (255) of research active academic staff in Life Sciences at these institutions were working in the field of Veterinary Science.

Students (PhD)

In 2005/06, some 645 PhDs were awarded in fields relating to the Life Sciences sector. The University of Edinburgh conferred awards upon 210 (or 33%) of the total, with Glasgow (150), Aberdeen (90) and Dundee (60) all playing a key role. The top 4 HEIs delivered 80% of Scotland's Life Sciences PhDs.

Figure 3.4: Number of Life Sciences PhD awards in 2005/05



Source: HESA, 2005/06; adapted by DTZ

3.1.5 Delivery

Table 3.1 and Figure 3.5, below, show the absolute and relative levels of Proof of Concept outcomes for life sciences. The absolute numbers and values for the industry are considerably higher than those of other industries. However, the success rate of awards against application is lower than other priority sectors – 5% lower in terms of numbers and 3% in terms of the value. The success rate in terms of value is lower than that of numbers but the average success rate shows a similar disparity.

Figure 3.5 illustrates that there was a peak of awards allocated in Round 3 – 5, but since then numbers have fallen. This trend is reflected in the value of awards, which shows a peak in Round 3, followed by high values in Round 4 and 5.

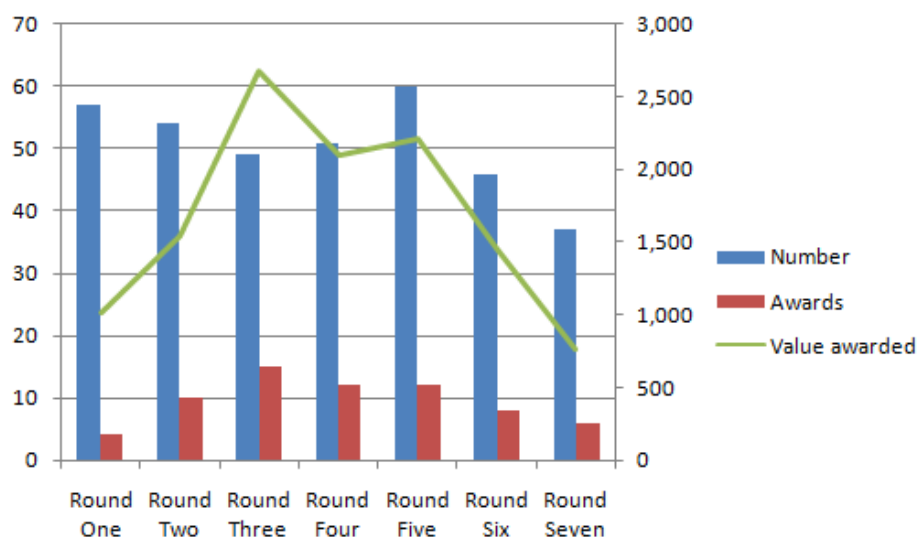
Table 3.1: Proof of Concept Applications, Awards and Success rate

	Number	Value
Applications	354	£78.9m
Awards	67	£11.7m
Success rate	19%	15%
Average success rate (Scotland)	24%	18%

NOTE: Includes Round 1 to 7 only.

Source: Scottish Enterprise

Figure 3.5: Proof of Concept Applications, Awards and Values



Source: Scottish Enterprise

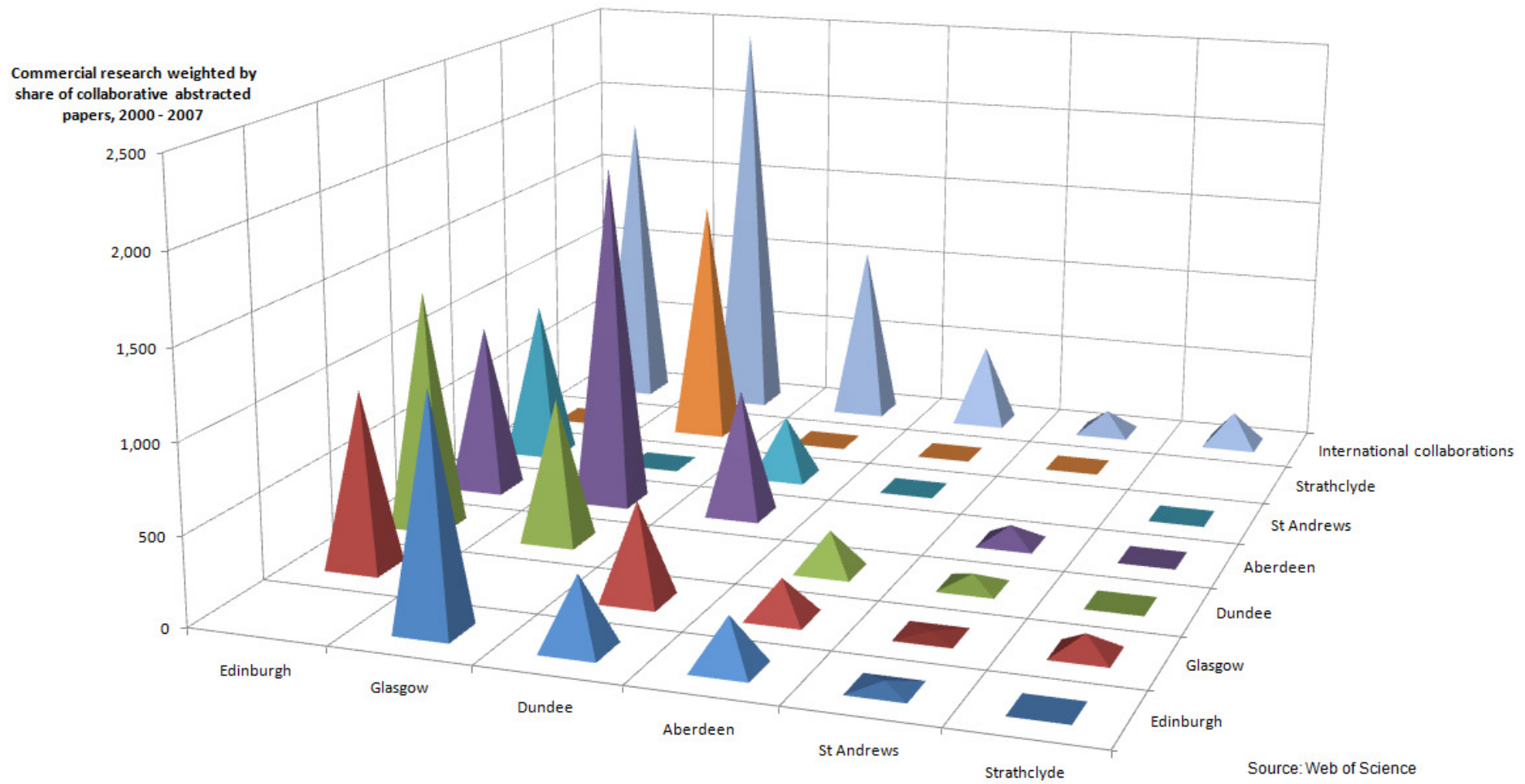
For the majority of institutions, the most common area of life sciences research lies within biochemistry & molecular biology, which represents around 6-7% of all publications across all institutions. The exception is the University of Aberdeen with around 5% of all publications in Endocrinology & metabolism.

Table 3.2: High impact institutions

Institution	Income and Expenditure £ million		Staff FTE	Research Only Staff FTE	Workforce		Delivery	Rank
	Research Income	Commercial/ Charities Research Income			Teaching and Research FTE	PhD Awards		
Edinburgh	£66.5	£31.1	1,978	655	412	210	Biochemistry & molecular biology	1
Glasgow	£50.3	£26.7	1,443	366	466	150	Biochemistry & molecular biology	2
Dundee	£37.2	£20.4	1,207	403	296	60	Biochemistry & molecular biology	3
Aberdeen	£34.4	£10.2	1,034	423	249	90	Endocrinology & metabolism	4
St Andrews	£10.0	£1.9	309	108	81	40	Biochemistry & molecular biology	5
Strathclyde	£5.3	£2.7	334	75	117	25	Pharmacology and pharmacy	6
ALL Scotland	£209.8	£94.6	7,356	2,156	2,076	645	-	

Institutional linkages are shown on the figure below. These are measured by the joint research publications between institutions weighted by the size of each institution's commercial research income. The figure shows that there is extensive collaboration in Life Sciences between the high impact institutions in Scotland, and mostly the collaboration is spread across different partners and there does not seem to be one dominating relationship above others. Furthermore, there is widespread collaborative research taking place between Scottish and international institutions.

Figure 3.6: Institutional linkages between high impact institutions



Specific areas of interest

The Scottish Centre for Regenerative Medicine (CRM) is based at Little France, Edinburgh. The CRM brings together, into a single unit, clinicians from the University of Edinburgh Medical School with existing research groups, who have a proven track record in clinical stem cell research and therapy, from the Institute for Stem Cell Research. CRM claims to be one of the largest critical masses of basic and clinical researchers in its field in Europe. From 2010, CRM will be co-located in a new state-of-the art building on the site shared by the Edinburgh Royal Infirmary and the University's clinical research facilities.

Easter Bush Research Centre (EBRC) is another key project and will be almost unique in the global Life Sciences sector. It will be the largest centre of its type in Europe and will be in the top 3 in the World in Animal Health, linking large animal health issues, human health and biochemicals. Partners include Roslin Institute, the Royal (Dick) Veterinary College, Edinburgh, Moredun Institute, SAC and the Neuropathogenesis Unit (NPU) of the University of Edinburgh.

Professor Sir Philip Cohen based at the College of Life Sciences, Dundee University, was frequently cited as a key source of commercial activity with current interests in pathogenic infection. Other cited income arose from Professors Sir David and Birgit Lane, Division of Molecular Medicine also at Dundee University. Dundee academics were instrumental in securing major investment for Dundee from Millipore centred on drug discovery and a German investment centred on microsurgery.

Associated research expertise is also important. For example, the Robertson Centre for Biostatistics is an essential part of the research pool and facilitates high-value clinical studies. University of Glasgow claim the Centre is responsible for data analysis for some 70% of clinical trial results in Scotland, with particular success in areas such as cardiac and cardiovascular systems; peripheral vascular disease; clinical neurology and haematology.

Medical devices have a shorter time to market and Strathclyde's Medical Research Institute is a leader in new product development of this type and has strong company linkages. For example relationships with Lifescan and Johnson and Johnson were cited.

The University of Aberdeen-Rowett Institute and University of Edinburgh-Roslin Institute mergers will both offer significant opportunities for synergies and 'bigger science'.

3.2 Energy

3.2.1 Overview

Energy industries are strategically important and contribute significantly to the Scottish economy. The Energy sector accounted in 2005/06 for a quarter (25%) of all annual research income for Scottish universities, around £98 million. Scotland accounted for 11.3% of all Energy research grants and contracts income within the UK HE sector.

The Industry's strategy is to both maintain Scotland's share of the UK oil and gas, power generation and renewable energy related expenditure, and maintain Scottish employment in the domestic sector.

Scottish Enterprise's Energy team highlight that Energy is a very wide sector, encompassing hydro, oil, gas, nuclear, coal and renewables. Therefore for the purposes of providing bespoke support, SE divide the energy research infrastructure into 3 subsets, namely:

- **Oil and Gas** – which SE are anticipating will eventually diminish in significance, although current estimates suggest that the industry may have in the region of 25-30 billion barrels of oil left to extract. Industry commentators have interpreted this as indicating that there may possibly be oil and gas activity, to some degree, may still be present in Scotland for another 40 years or more. The SE Energy Strategy states that the ambition is to build overseas sales from Scottish oil & gas companies, growing from £2.7 billion in 2002 to £5 billion per annum by 2010;
- **Renewables** – growing rapidly with ambitious Scottish Government, UK Government and European Union targets for increasing the proportion of energy, electricity in particular, generated from renewable sources. The Scottish Government target for renewable energy states that in 2010 18% of Scottish electricity demand is to be produced by renewable sources, and by 2020 this level should be 40%; and
- **Power Generation** – not only research in respect of generation technologies but also in relation to tackling the environmental impacts of power generation. Particular effort is being devoted to providing technologies that can facilitate carbon capture, or indeed a range of research on energy conservation technologies. This area is seen as also being an area for expansion of research projects.

It is hoped that a forecast decline in offshore oil and gas in the longer term can be balanced by growth of employment in renewables and in respect of nuclear energy. In the case of the latter, the Scottish Government has announced its determination to use its planning powers under the Scotland Act to prevent any new nuclear stations being built in Scotland. Even if this is the case, there may yet be commercial opportunities to be exploited across the UK and overseas, while there is a considerable industry building up around decommissioning of existing nuclear sites.

SE and Commercialisation directors have highlighted that one of the key distinguishing characteristics of the Energy sector is that research will simply not happen unless it has an application in the market. This means that *"the overwhelming majority of energy research has commercialisation potential"*.

It is asserted by SE that Oil and Gas and renewables employers are already making a significant contribution to research in the Energy sector and that there are substantial flows of funds from UK based oil and gas operators, but also from some from international players, such as Chevron. However, research funding can be difficult to track and this has led to the investment in a bespoke database, as set out later in this section, which has meant that SE Energy team have been very successful in accurately tracking flows of public sector funding into Energy –related research.

SE have highlighted the need for a twin-track approach to identifying research opportunities, i.e. need for new blue skies research to be allied to research to secure further technological developments of existing research/ideas.

In terms of commercialisation, the University of Edinburgh spin-out, MTEM, has been cited as a case in point, with commercial development of existing seismic research and research on electromagnetism. This was not blue skies research, but rather a major development or breakthrough in existing technologies or research.

One of the most significant commercial drivers for Energy related research, and the industry itself, is to reduce costs and increase reliability of existing technologies. Examples of these might include improving the relationship between costs and benefits for micro-renewables or working on improving anti-corrosion in marine or offshore wind project technologies, to increase their lifespan and improve ongoing efficiency and reliability.

The Energy team have an ambition to stimulate research collaboration. Over the period 2007/08, they established the **Energy Technology Partnership (ETP)**, i.e. a single unified partnership to undertake collaboration. The Energy Technology Partnership is comprised of the Universities of Strathclyde, Glasgow, Edinburgh, Aberdeen, St Andrews and Heriot-Watt. In particular, EPT is seen as being vital to unlock opportunities arising from EU Framework 7 funding.

ETP are trying to work closely with the **UK Energy Technologies Institute (ETI)**⁶, based at Loughborough University, to source a share of up to £1 billion in funding that ETI will disburse to fund energy related research. Programmes cover offshore wind and marine, tidal & wave technologies, while significant collaborations include working with the Carbon Trust on Offshore Wind programme.

Alongside the ETP, there are pockets of expertise among the academics engaged in both ScotCHEM (see Chemical Sciences Note) and Scottish Universities Physics Alliance (SUPA). It is understood that the Energy team view there to be great potential for work with Chemical Sciences to further work in the area of thermal engineering and power.

⁶ Potentially £1 billion will be invested by the ETI over 10 years. Partner organisations include: BERR, E.ON UK, the Government Office for Science, EDF Energy, Shell, BP, Caterpillar and Rolls Royce. ETP was itself an unsuccessful short-listed bidder for the location of the centre. Selection Panel criteria for ETI projects include: expertise or capability to contribute to the development and demonstration needs in marine wave and tidal stream energy, including previous work in marine energy and/or transferable expertise; evidence of a collaborative approach; a track record of innovation; a track record of delivery.”

Scotland is already seen to be a leader in terms of fuel cell technology. While this is generating a lot of income, in the short-term it may not have high impact on the economy.

Biofuels and transport related energy research are areas where provision is poor at the moment. There are one or two pockets, but Scotland's expertise in 2nd generation biofuels is an area that requires more attention. There is, again, potential to work with chemical Sciences on this.

3.2.2 Key Academic Centres

SUPA's concept is to build the alliance around key research strengths on which there is multi-institutional agreement including: (a) Astronomy and Space Physics, (b) Condensed Matter and Material Physics; (c) Nuclear and Plasma Physics, (d) Particle Physics, (e) Photonics. The key pillars of SUPA are a Scottish Graduate School in Physics and a coordinated approach to research under a single management umbrella. Departments engaged in SUPA are as follows:

- University of Edinburgh - School of Physics;
- University of Glasgow - Department of Physics & Astronomy and Institute for Gravitational Research;
- Heriot-Watt University - School of Engineering and Physical Sciences;
- University of the West of Scotland (at Paisley) - Institute of Physical Research;
- University of St Andrews - School of Physics & Astronomy; and
- University of Strathclyde - Department of Physics, and the Institute of Photonics.

The key individuals identified by SE Energy team are set out below. For further details of the key academics engaged in driving collaborative research by SUPA see SUPA's website⁷. However, further details of the various work streams in this key collaborative network are presented at the end of the section.

Professor Patrick Corbett is the Head of Institute of Petroleum Engineering of Heriot Watt University. His current research interest lies in well testing, petrophysics, sustainability and geoengineering. Before joining Heriot Watt in 1989 he worked in industry in the UK and abroad for international explorations and development geoscience.

Professor Robin Wallace is Head of The Institute for Energy Systems at University of Edinburgh. His research interests include network integration of distributed renewable energy generation and marine energy. He is Principal Investigator and Finance Lead of the EPSRC SuperGen Marine Energy Research Consortium and Co-Director of the UK Energy Research Centre.

⁷ http://www.supa.ac.uk/Graduate_School/resources/people/SUPA_Committees.pdf

Professor Jim McDonald is Deputy Principal at Strathclyde University and his role focuses on research enhancement and commercialisation, and he is also Director of the Institute for Energy and Environment. He completed his MSc and PhD Degrees in Power Engineering and Power System Economics. In October 2006 he was appointed Director of the Glasgow Research Partnership (GRP), part of a major research pooling investment by the Scottish Funding Council and the GRP that brings together the Engineering Faculties of Strathclyde and other universities in large-scale research collaboration.

Professor John Irvine is Professor of Inorganic Chemistry at St Andrews University and he is also Vice Chair of ESF COST Action 543 on Bioethanol. He obtained his BSc in Chemical Physics, his D.Phil in photoelectrochemistry. His research interests are in the study of inorganic materials, at the interface between solid state chemistry, condensed matter physics and ceramics. He has an international profile and has led a successful EU TMR Network bid for a project on SOFC Anodes with leading European Laboratories as partners, for example Aveiro, Rixs, Patras, and British Gas.

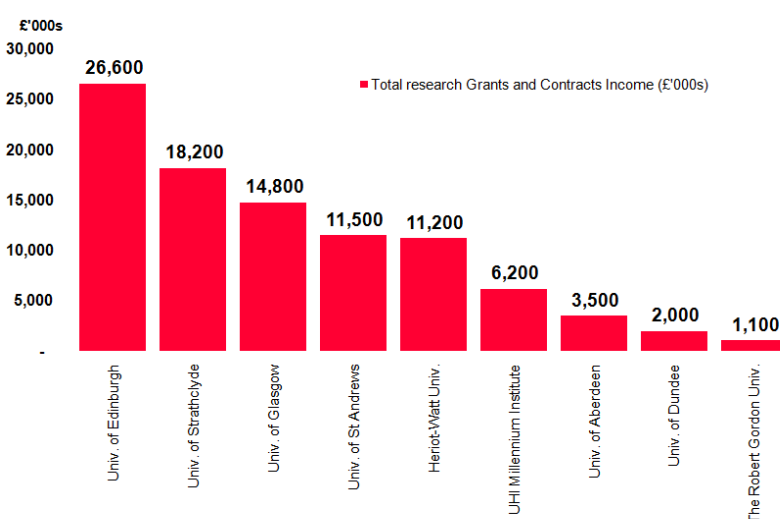
3.2.3 Income and expenditure

Research income (£ thousands)

The University of Edinburgh dominates Energy sector research in terms of research grants and contracts income with just over £26.6 million in (2005-06) or 27% of the total for Scotland.

When combined, Edinburgh, Strathclyde, Glasgow, St Andrews and Heriot-Watt account for around £82.3 million, or 84.4% of all Energy-relevant research grants and contracts income (£97.6 million)..

Figure 3.7: Total Research Grants and Contracts Income



Source: HESA, 2005/06 data

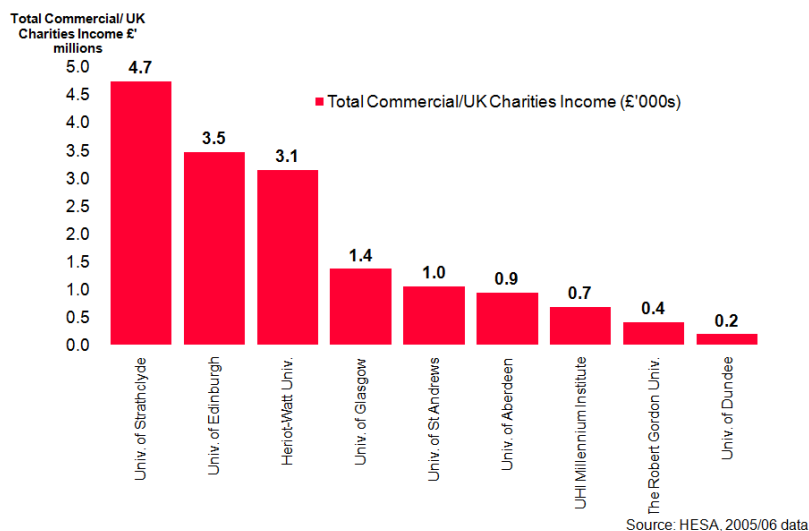
The University of Edinburgh has, in absolute terms, the largest Energy sector research income stream, and this accounts for 23.4% of all research grants and contracts income for that university. However, the UHI Millennium Institute (81% of all research is in relevant subjects), Heriot-Watt University (74%) and University of Strathclyde (63%) are, in relative terms, the most Energy focused universities in Scotland in terms of the share of all research grants and contracts income coming from Energy research or subjects that could be applied to that area.

Commercial research income in Energy

The top four universities account for £12.7 million or 78% of all commercial and UK charities research income received for research activities in Scotland (£16.2 million).

Edinburgh (13%), Glasgow (9%) and St Andrews (9%) are all relatively less reliant on commercial income and charitable income, but Robert Gordon (35%), although modest in scale, Heriot-Watt (28%), Strathclyde (26%) and Aberdeen (26%) draw the greatest proportion of their research income from these sources.

Figure 3.8: Total Commercial / UK Charities Income (£'000s)

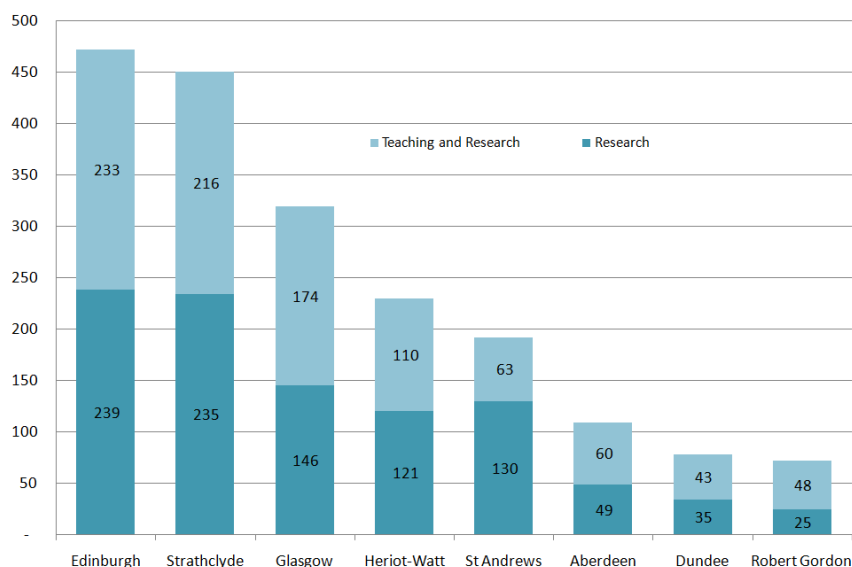


3.2.4 Workforce

Staff

In 2005/06, HESA data indicate that some 3,703 staff were employed by Scottish universities in the field of Energy related activities. Of the total, 63% work at the top four universities, i.e. Edinburgh, Strathclyde, Glasgow and St Andrews. Energy-related staff make up 10.9% of all University staff, of all grades, employed in Scotland in 2005/06. Collectively, Energy activity is bigger in scale than the Universities of Aberdeen

Figure 3.9: Staff numbers



(2,820), Dundee (3,060) or Strathclyde (3,090) and, like Life Sciences, in a virtual sense, Energy activity is large enough to be regarded as a university in its own right.

Research staff

Within Scotland, there were nearly 1,040 staff employed exclusively in academic research positions, i.e. 'research only', while a further 1,140 staff are in posts combining teaching and research functions. Hence, 2,180 academic professionals were engaged in pursuit of Energy related research to some degree. This accounts for 17.1% of all Scottish academic professionals working in research. For 'Research Only' staff, Energy accounts for 24% of the total 4,260 employed in Scotland, while these disciplines employ 14% of staff engaged in both teaching and research.

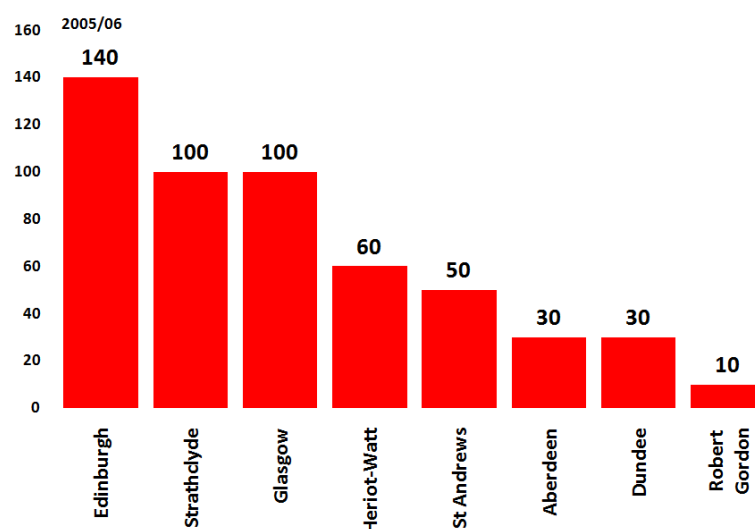
Edinburgh, then Strathclyde has the most staff in dedicated research functions, while Glasgow has greatest dependence upon staff engaged in both teaching and research.

By discipline, Physics accounts for 25% of all research active academic staff in Scotland, while Chemistry (21%), Electrical, electronic and computer engineering (16%) and Mechanical, are and production engineering (15%) were the other main areas. Earth, marine and environmental sciences were also significant (12%).

Students (PhD)

In 2005/06, across the top 8 HEIs, some 520 PhDs were awarded in fields relating to the Energy sector. The University of Edinburgh conferred awards upon 140 (or 27%) of the total, with Glasgow (100), Aberdeen (100), Heriot-Watt (60) and St Andrews all playing a key role. The top 3 HEIs delivered 66% of Scotland's PhDs of relevance to the Energy sector.

Figure 3.10: Number of Energy-related PhD awards in 2005/06



3.2.5 Delivery

The top three institutions in terms of Commercial income are Edinburgh, Strathclyde and Heriot-Watt. Together they account for 70% of all energy related commercial income across Scottish universities. At the Institute of Energy & Environment of Strathclyde University around two thirds of publications and citations are in electrical and electronic engineering, while at the Institute of Photonics of Strathclyde the main research are is applied physics, with almost half of the cited research in this area. At the Centre of Materials Science and Engineering at University of Edinburgh, the majority of research is in applied physics and materials science, and around half of abstracted papers between 2000 and 2007 were in these two fields.

3.2.6 Commercialisation

The number of Proof of Concept awards to the Energy sector is deemed to be acceptable, but more could be achieved. Energy projects do have a distinct advantage in terms of commercialisation in comparison with other sectors, as the sector has been able to point universities towards areas where there is a significant market focus.

However, from consultations, it is apparent that many companies may do seek to acquire the Intellectual Property (IP) rights when establishing partnerships with Universities, and that this can be problematic. In practice, in most cases the IP will stay with the university at present.

Table 3.3 and Figure 3.10 show the absolute and relative levels of Proof of Concept awards over Round 2 to 7. Energy has the fourth highest level of applications and awards amongst the priority industries. The success rate is higher than the average, both for the number of awards and the value awarded. The peak of awards and their values took place in Round 2, with a second peak in Round 4.

Table 3.3: Proof of Concept Applications, Awards and Success rate

	Number	Value
Applications	69	£13.1m
Awards	19	£3.1m
Success rate	28%	23%
Average success rate (Scotland)	24%	18%

NOTE: Includes Round 2 to 7 only.

Source: Scottish Enterprise

Figure 3.11: Proof of Concept Applications, Awards and Values

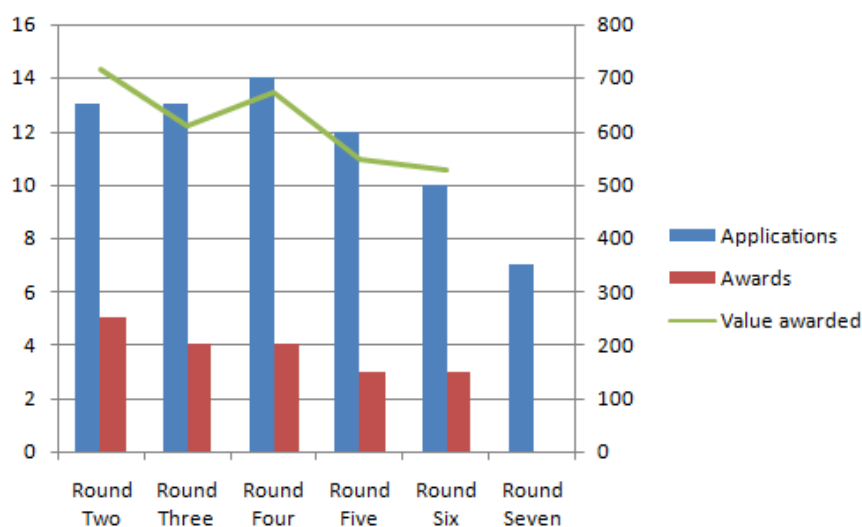
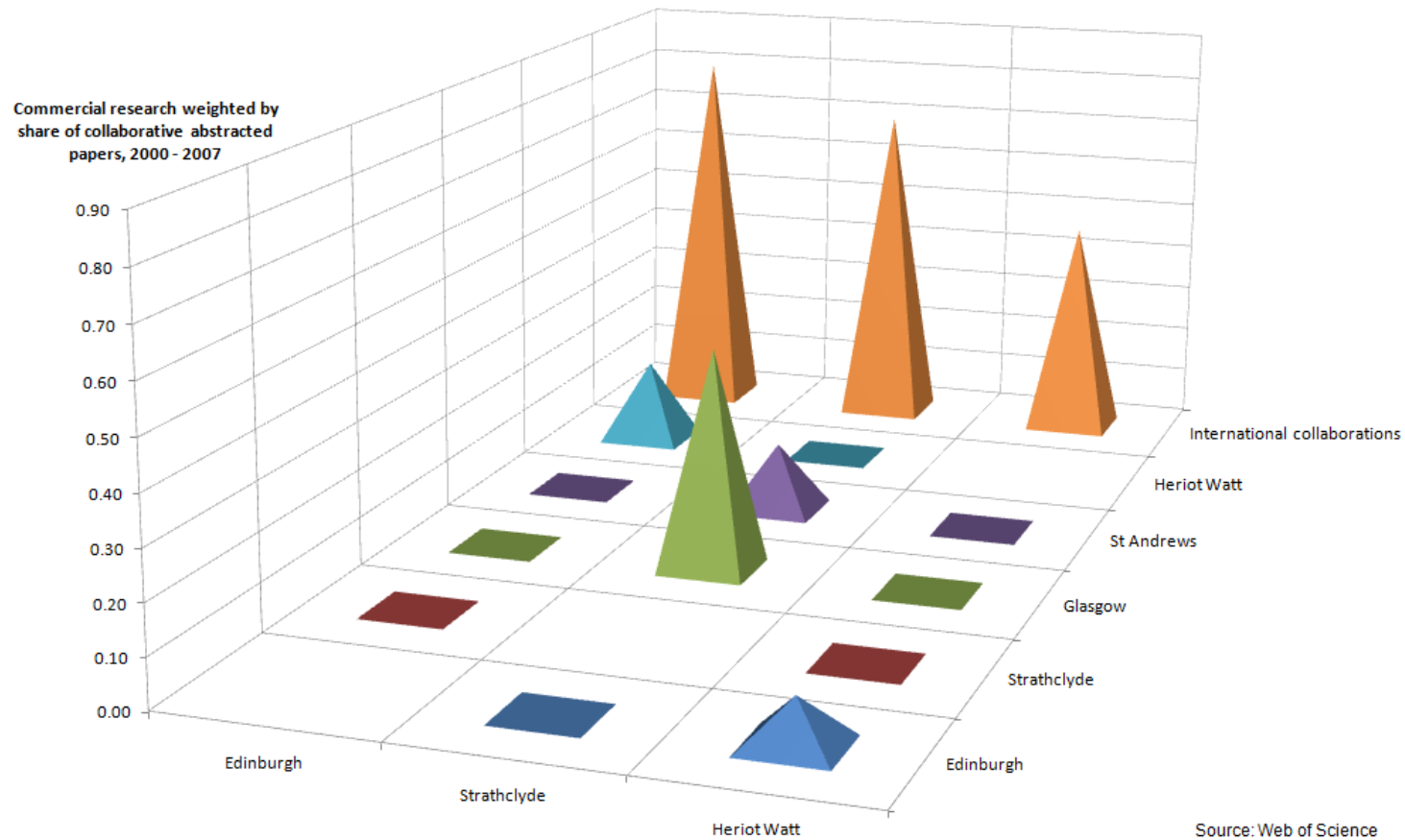


Table 3.4: High Impact Institutions

Income and Expenditure £million			Workforce		Delivery			Rank
Institution	Research Income	Commercial/ Charities Research Income	Staff FTE	Research Only Staff FTE	Teaching and Research FTE	PhD Awards	Most Common Publications and Citations	
Edinburgh	£26.6	£3.50	792	239	233	141	Applied physics / Materials science	1
Strathclyde	£18.2	£4.70	714	235	216	98	Electrical and electronic engineering / Applied physics	2
Glasgow	£14.8	£1.40	536	146	174	99	-	3
St Andrews	£11.5	£1.00	289	130	63	51	-	4
Heriot-Watt	£11.2	£3.10	354	121	110	58	Chemical and petroleum engineering	5
Aberdeen	£3.5	£0.90	170	49	60	34	-	6
ALL Scotland	£85.8	£14.60	2,855	920	856	481	-	

The graph below includes the top three institutes in Scotland in terms of commercial income. These are measured by commercial research income weighted by the share of joint research publications between institutions in Scotland, and as an aggregate for international collaborations. For example, Edinburgh, Strathclyde and Heriot-Watt have strong linkages with international institutions, and a large share of the energy specific research undertaken in Scotland is in collaboration with academic and commercial institutions outside Scotland. Edinburgh, Strathclyde and Heriot-Watt all have some linkages to other key universities in Scotland and Edinburgh and Heriot-Watt has undertaken joint research. Strathclyde has very strong linkages with Glasgow University and some with St Andrews University.

Figure 3.12: Institutional linkages between high impact institutions



NOTE: The institutions included in this analysis are the Institute of Energy & Environment, University of Strathclyde; Institute of Petroleum Engineering, Heriot-Watt University; Centre for Materials Science and Engineering, University of Edinburgh; and Institute of Photonics, University of Strathclyde.

Specific areas of interest

In order to track research in what is a wide sector and which has a dispersed network of research projects and centres, the SE Energy team have commissioned a live, updated database from Professor Jim Murray, a retired university professor, regarding the success of universities in developing their research base in relation to Energy.

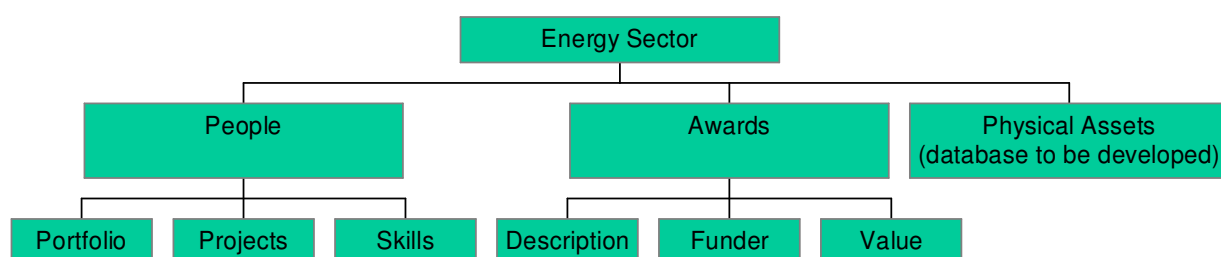
DTZ were afforded an opportunity to meet with Professor Murray who has also prepared an *Energy Research Hot Spots Paper* which summarises monitoring data on research hot spots for principal researchers drawing down £10k or more of income, from sources such as Research Councils, Carbon Trust, KTP, Europe (Framework VII).

The database that has been gathered focuses on the human asset base for energy research and is weaker in terms of physical assets. SE Energy feel that this is an area that could be enhanced, but this has not yet taken place.

In terms of principal researchers, the database covers projects, project title, project description (including who works on the project and project research objectives), expertise and funders, i.e. every grant received. Researchers are also analysed in terms of sector, domain, expertise, specialism, and other characteristics.

The aim is to provide an asset register, in effect, and to then try to match this to industry demand for research. In such a way it will be possible to ensure as good a fit between the two. The current database structure and potential for extension to include physical assets is shown below:

Energy Sector Research Asset Database - identification of Hot Spots



As just one example, Heriot-Watt University is undertaking pioneering research in petroleum engineering and seismology; these are areas where there has been a considerable degree of oil companies taking an interest. However, SUPERGEN is the key area of research pooling for Energy, as set out below:

3.2.7 Scottish University engagement in EPSRC funded SUPERGEN Consortia

SUPERGEN Fuel Cells⁸ is a consortium tackling the considerable challenges associated with making powerful, durable fuel cells. Researchers are working on three types of fuel cell technology and considering how cells can run on a variety of fuels including anything from bio alcohol to diesel. Consortium partners are Imperial College London, University of Newcastle, University of Nottingham, **University of St Andrews**, Ceres Power Ltd, Defence Science and Technology Laboratory, Johnson Matthey plc and Rolls-Royce Fuel Cell Systems Ltd.

SUPERGEN Excitonic Solar Cells⁹ - these are made from organic compounds, dyes, gels or liquids rather than the conventional silicon. Light absorption leads to electronically excited molecular states called excitons. Excitons transfer energy between molecules for a few tens of nanometres until they reach an interface between two materials where the energy is used to create an electron in one material (phase) and a hole in the other, creating an electrical current. Consortium partners are the University of Bath, University of Cambridge, **University of Edinburgh**, Imperial College London and Cambridge Display Technology.

SUPERGEN Energy Storage Consortium¹⁰ will be developing new materials to improve rechargeable lithium ion battery and supercapacitor technology. The new technologies could be very important for storing energy from renewable resources and for using in hybrid electric vehicles. Led by the Universities of Strathclyde and Bath (£2.2 million over 4 years). Consortium partners are the University of Bath, **University of St Andrews**, University of Surrey, AEA Technology, Huntsman, Johnson Matthey, Mast Carbons, Rolls Royce and Valence Technology.

The **SUPERGEN Marine Energy Research Consortium¹¹** is tackling a wide range of challenges associated with wave and tidal power and involves a large number of industry partners. Prototype devices exist for generating marine energy, but there is still a lot to learn about marine energy resources and ways to efficiently harness them and feed energy into networks. The consortium is aiming to make marine energy more attractive to investors, reducing investment risk and uncertainty through greater knowledge. Led by Robert Gordon and Edinburgh Universities (£2.6 million over 4 years). Consortium partners include the **University of Edinburgh**, **Heriot-Watt University**, Lancaster University, **Robert Gordon University**, **University of Strathclyde**, EMEC Orkney, Talisman Energy, Umitech, Corus, Marine Current Turbines, The Engineering Business, IT Power, Siemens PTI(UK), Ocean Power Delivery, Artemis Intelligent Power Ltd, Edinburgh Designs, South West Electrolysers, Natural Power Company, Entec, Conoco Europe Ltd, INEOS Chlor, Scottish Power, Scottish and Southern Energy, QinetiQ, SEPA, SNH, CEFAS, HIE, Crown Estates, Met Office, Sgurr Energy, Wavegen and Lunar Energy.

8 <http://www.epsrc.ac.uk/ResearchFunding/Programmes/Energy/Funding/SUPERGEN/FuelCells.htm>

9 <http://www.epsrc.ac.uk/ResearchFunding/Programmes/Energy/Funding/SUPERGEN/ExcitonicSolarCells.htm>

10 <http://www.epsrc.ac.uk/ResearchFunding/Programmes/Energy/Funding/SUPERGEN/EnergyStorage.htm>

11 <http://www.epsrc.ac.uk/ResearchFunding/Programmes/Energy/Funding/SUPERGEN/MarineEnergyResearch.htm>

The **SUPERGEN Future Network Technologies Consortium**¹² is researching ways to integrate small-scale renewable energy sources into the electrical energy system, and looking at how energy networks may need to develop in the future. Led by Imperial College London and the **University of Strathclyde** (£3.4 million over 4 years). Consortium partners are the University of Bath, University of Cambridge, **University of Edinburgh**, De Monfort University, University of Hull, Imperial College London, University of Manchester, **University of Strathclyde**, ABB, Areva T&D, Corus, Countryside Agency, DBERR, Econnect, Edison Mission Energy, EDF Energy, Garrad Hassan, ICF Consulting, INREB, National Grid Transco, New and Renewable Energy Centre, Rolls Royce, Scottish Power, Scottish and Southern Energy, Scottish Renewables Forum, The Carbon Trust, Toshiba, United Utilities, Unst Partnership, URBED and Westmill Wind-Cooperative/Energy4All.

The **SUPERGEN Highly Distributed Power Systems Consortium**¹³ is researching networks of small energy generators and storage devices. This consortium is investigating how to co-ordinate many small distributed energy resources to form a highly distributed power system, sometimes called a micro-grid. Research will discover whether network support should be provided by co-ordinating many low cost distributed sources or concentrated in larger equipment. Led by Strathclyde and Loughborough Universities (£2.6 million over 4 years). The consortium is tackling design of power systems, frameworks for operating and appraising power systems, and integrating distributed energy resources. Consortium partners are Imperial College London, University of Bath, Loughborough University, University of Manchester, University of Oxford, **University of Strathclyde**, Econnect, EDF Energy, Rolls-Royce plc and ScottishPower.

In addition the SUPERGEN Biomass, **biofuels and energy crops**¹⁴ consortium is looking at using fast growing crops as a renewable fuel supply. Led by Aston and Leeds Universities (£2.9 million over 4 years). Scottish Association for Marine Science (SAMS) at Dunstaffnage, Argyll is an associate member of this consortium.

¹²

<http://www.epsrc.ac.uk/ResearchFunding/Programmes/Energy/Funding/SUPERGEN/FutureNetworkTechnologies.htm>

¹³

<http://www.epsrc.ac.uk/ResearchFunding/Programmes/Energy/Funding/SUPERGEN/HighlyDistributedPowerSystems.htm>

¹⁴ <http://www.epsrc.ac.uk/ResearchFunding/Programmes/Energy/Funding/SUPERGEN/BiomassAndBioenergy.htm>

3.3 Digital Markets and Enabling Technologies

3.3.1 Overview

Electronic Markets is the term given to the Technology and Digital Media industries which have increasingly converged. In the Technology sector, the end markets for companies are often other Priority Industries including Life Sciences, Financial Services, Energy and Defence and Aerospace. Therefore the role of this sector has increasingly moved towards working with Enabling Technologies and Engineering to develop the innovative, new technologies underpinning rapid growth in other key industries.

Scotland has suffered from the transfer of high-volume manufacturing in electronics to lower cost economies. However, it has successfully retained a presence in high-value manufacture and design, with successes including Wolfson Microelectronics and Intense Photonics. Areas that have potential high growth potential include Wireless and Mobile Applications, Intelligent Transport Systems and Security.

The Digital Media industry in Scotland has a track record in the creation, development, production and distribution of high value products and services. Scotland has a particular presence in content creation including television and radio, publishing, music, interactive games and game-based learning.

The barriers to commercialisation in Electronic Markets are generally felt to be the same issues facing many technology companies rather than anything specific to the industry. These barriers include a lack of entrepreneurial skills amongst those in the technology arena and a lack of skilled marketers who have the capability to integrate marketing to the process of product development. Availability of finance is a particular issue for the Digital Media industry, as commercialisation is often based on projects rather than businesses so traditional equity routes do not apply. There is also often confusion over who should be funding university spin-out activity – the Enterprise Network or the Funding Council. The absence of companies of scale in Scotland is also regarded as a barrier to commercialisation.

3.3.2 Key Academic Centres

The key players in the Technology industry in terms of research are Edinburgh, Strathclyde and Glasgow Universities. Edinburgh University School of Informatics is a 5*A rated department and the top in the UK, the university states that the school is the largest of its kind in the UK. The Department is headed by Professor Michael Fourman. The School attracts research grant income of £5m per annum.

Strathclyde University is home to the Institute of Photonics and the Institute's semiconductor growth and processing equipment is located at Photonix Ltd on the West of Scotland Science Park along with equipment from Glasgow University. The Institute's research interests include semiconductor materials and devices, practical, all solid state lasers, micro-LED arrays and a wide range of applications particularly in biophotonics. The Institute has leveraged over £16 million in competitively won grants and contracts and currently holds the 4th largest portfolio of EPSRC grants in the University, worth over £6m.

Glasgow University Electronics and Electrical Engineering (EEE) Department has held one of the top positions in the RAE for the last 15 years and has more citations for published research than any other UK EEE department. The department, headed by Professor John Arnold currently has a research grant portfolio of over £28m.

There are Digital Media strengths in Glasgow School of Art and the University of the West of Scotland (formerly Paisley University). Glasgow School of Art's Digital Design Studio (DDS) is successful in supplying skilled people to work in the industry. The University of the West of Scotland is a key player in film design. The University of Abertay is one of the best in the UK in terms of producing qualified people to work in the games industry, but does not undertake research.

The ITI Techmedia has an Online Games Development R&D Programme and is investing £5.35m to investigate and address the requirements of game developers facing the unique challenges posed by online game design. ITI Techmedia has also invested £1.9m in a two year programme to develop an authoring platform that will greatly simplify the process of developing Games-Based Learning content for training and educational purposes and TPLD (Team Play Learning Dynamics), the Scottish Games-Based Learning specialists, signed a license agreement to utilise the new technology in 2007.

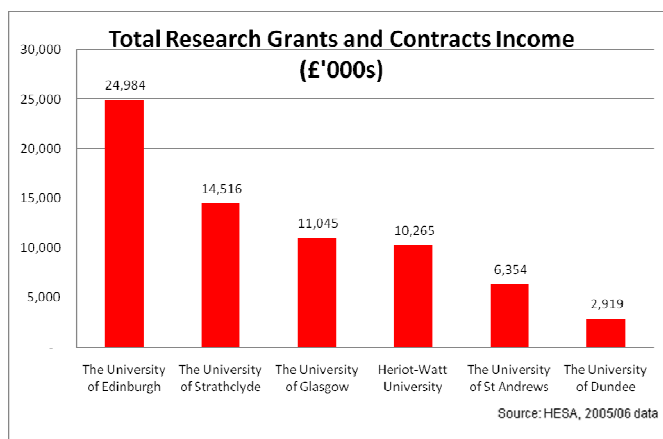
3.3.3 Income and Expenditure

Total Research Income

The digital markets and enabling technologies industry generated a total of £78 million in research income, dominated by the University of Edinburgh which accounts for 32% of the total sector research grants and contract income (£25 million).

The other four major universities (in terms of research and grant contract incomes) are the University of Strathclyde (19%), the University of Glasgow (14%), Heriot-Watt University (13%), the University of St. Andrews (8%) and the University of Dundee (4%) respectively.

Figure 3.13: Total Research Grants and Contracts Income



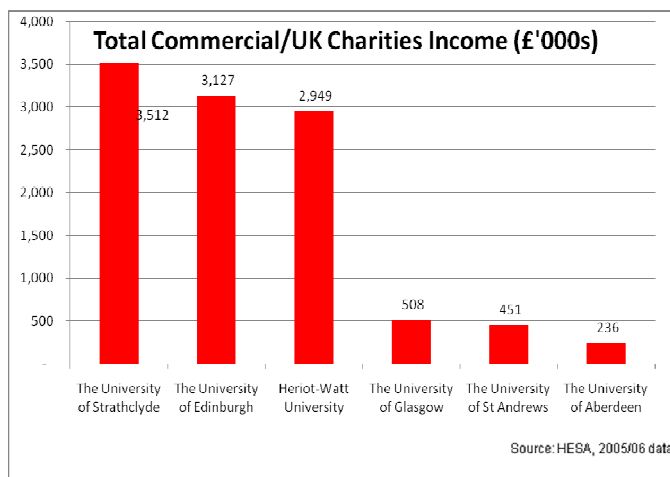
Additionally the industry is a major income earner for the top five universities accounting for as much as 66% of the University of Heriot-Watt, 51% of the University of Strathclyde and at least a fifth of the other top five universities' total research grants and contracts income. The University of Glasgow however is relatively less dependent on the industry which accounts for 15% of the total research grants and contracts income.

Commercial Research Income in Digital Markets and Enabling Technologies

The profile of the top five universities in terms of total commercial and UK charities income is slightly different to that of the total research grant and contract income. The University of Glasgow which ranks third amongst the top five research grant and contract income earners, ranks fourth amongst the top five total commercial and UK Charities income earners.

The top five universities account for £10.5 million or 88% of all commercial research income in the digital markets and enabling technologies industry in Scotland. The University of Edinburgh is the biggest in the sector accounting for 29% (£3.5 million) of the total commercial and UK charities.

Figure 3.14: Total Commercial / UK Charities Income



3.3.4 Workforce

Staff

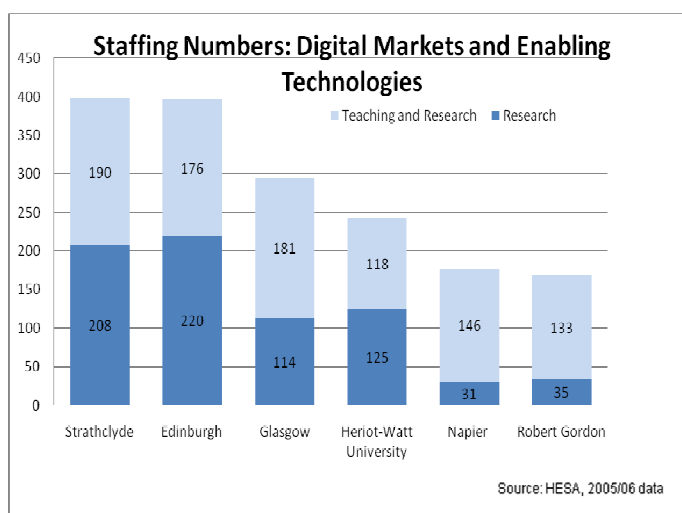
2005/06 HESA data indicates that Scottish universities employed a total of 4,253 in the digital markets and enabling technologies industry.

Research Staff

Of the total staff employed in the sector, 57% (2,444) are involved in either research or research and teaching work.

The top six universities employ 70% of all staff employed by Scottish universities in research related work in the industry. The universities of Strathclyde, Edinburgh, Glasgow and Heriot-Watt display a near balance between the number of academics working in research related work only and those working in both research and teaching. The remaining institutions show a heavy bias towards academics involved in both research and teaching.

Figure 3.15: Staffing Numbers



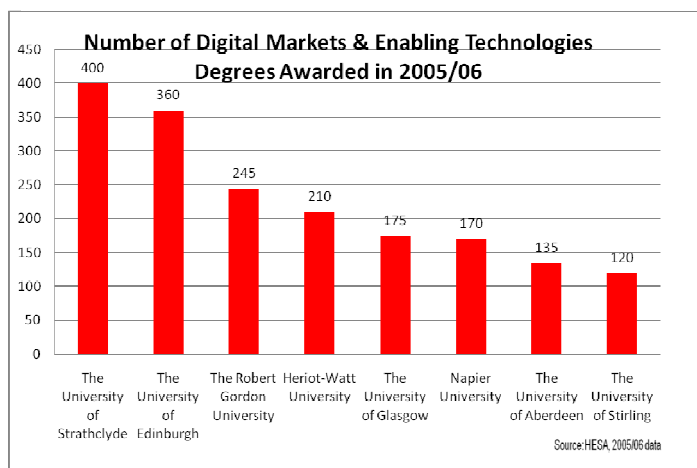
Students

According to HESA data, 2,145 digital markets and enabling technology related higher degrees were awarded in 2005/06. This accounted for 10% of all the higher degrees awarded in the industry in the whole of the UK and is at least three times the number of similar awards awarded in Wales during the same period.

Of these awards, up to 565 were at doctoral level with the majority of awards being in physical sciences (240) and engineering and technology (205).

The University of Strathclyde, University of Edinburgh, the Robert Gordon University and the Heriot-Watt University respectively accounted for 19%, 17%, 11% and 10% of the total higher degrees awarded.

Figure 3.16: Number of Degrees Awarded 2005/06



3.3.5 Delivery

Specific areas of interest

Micro and Opto Electronics

The Institute for System Level Integration (ISLI)¹⁵ is an academic collaborative venture between four Scottish Universities – Edinburgh, Glasgow, Heriot-Watt and Strathclyde – SLI Ltd and SE. ISLI aims to fill the gap between industry and academia within micro and opto electronics technology by building capacity and fostering world-class activity resulting in the growth of companies and the industry. Its research activities are in the areas of system design and system on chip technology. A recent evaluation of ILSI by DTZ found that over the period April 2005 to December 2007, the Institute has leveraged funding of £3.7m including research projects with the partner universities where ISLI is a direct partner. In addition, the partner universities identified a further £2m of funding that has been leveraged through their involvement in ISLI.

The Scottish Microelectronics Centre (SMC)¹⁶ is joint venture between the University of Edinburgh and Scottish Enterprise that provides incubation, reserach and development in the semiconductor sector. Areas of research strength include wireless drug delivery technology. Researchers at the SMC have successfully integrated drug delivery technology with wireless power transfer and communications to create a system which can deliver multiple doses of a drug on demand, potentially reducing the negative side effects associated with medication administered into the entire system.

¹⁵ <http://www.sli-institute.ac.uk>

¹⁶ <http://www.scotmicrocentre.co.uk>

High Performance Computing/Informatics

The FPGA (Field Programmable Gate Arrays) High Performance Computing Alliance (FHPCA)¹⁷ was established in 2004 and is dedicated to the use of Xilinx FPGAs to deliver new levels of computational performance for real-world industrial applications. Led by EPCC, the supercomputing centre at The University of Edinburgh, the FHPCA is funded by Scottish Enterprise and builds on the skills of Nallatech Ltd, Alpha Data Ltd, Xilinx Development Corporation, Algotronix and ISLI. In March 2007, the Alliance announced the completion of the supercomputer it has been designing and building since the start of the project - "Maxwell". The project hopes to revolutionise the development of "mission-critical applications" and help deal with the massive processing requirements needed in areas such as drug design, defence, seismology, medical imaging and mobile telecoms. The FHPCA has now successfully ported three numerically intensive applications to Xilinx FPGAs. These applications come from the Oil & Gas, Financial and Medical Imaging sectors.

The Edinburgh-Stanford Link¹⁸ is a £6m research, training and commercialisation initiative, specialising in speech and language technology. The initiative is a collaborative venture between the University of Edinburgh, Stanford University and Scottish Enterprise.

Games

International Centre for Computing & Virtual Entertainment (IC CAVE)¹⁹ is a research centre at the University of Abertay Dundee established to focus on the development of research to support the computer games and digital entertainment industry.

¹⁷ <http://www.fhpca.org>

¹⁸ <http://www.edinburghstanfordlink.org>

¹⁹ <http://iccave.tay.ac.uk>

Table 3.5: High impact institutions – Digital Markets and Enabling Technologies

Institution	Income and Expenditure £ million			Workforce			Delivery		Rank
	Research Income	Commercial/ Charities Research Income	Staff FTE	Research Only Staff FTE	Teaching and Research FTE	Higher Degree Awards	PhD Awards	Most Common Publications and Citations	
Edinburgh	£25	£3.1	686	220	176	360	..	-	1
Strathclyde	£14.5	£3.5	612	208	190	400	..	-	2
Glasgow	£11.0	£0.5	463	114	181	175	..	-	3
Heriot-Watt	£10.3	£2.9	386	125	118	210	..	-	4
St Andrews	£6.4	£0.5	159	68	44	15	..	-	5
Dundee	£2.9	£0.2	274	50	101	85	..	-	6
ALL Scotland	£78.0	£12.0	4,253	944	1500	2,145	120	-	

3.4 Aerospace, Defence and Marine

3.4.1 Overview

The aerospace, defence and marine sector sales in Scotland are worth over £2.28 billion and the sector exports £1.3 billion. Average GVA per employee is around twice as high as that found in manufacturing as a whole. There are over 180 companies operating in the sector and together these employ more than 16,200 people.

Aerospace and shipbuilding were previously treated as two separate priority industries but were recently merged to enable a better strategic fit with the recognised aim of collaborative projects and knowledge sharing. With skills development, innovation and business development the Scottish industry seeks to become internationally recognised as a major aerospace, defence and marine player.

Aerospace is the second largest contributor to the UK economy after pharmaceuticals, and approximately 10 per cent of the UK aerospace industry is based in Scotland. It is predominantly civil, based around the major international airports in Scotland.

The defence industry in Scotland consists of two elements – electronics and naval. In electronics there are over 100 companies employing almost 4,400 people and sales are worth over £684 million. In the naval industry Scotland plays a major role in maintaining the Royal Navy's surface ship and submarine assets.

The aim is to strengthen the reputation of Scotland as a hub of innovation and to create an environment whereby companies and universities get involved in collaborative R&D projects. There seems to be a situation whereby universities are an underused resource in aerospace, particularly so in Scotland where the existing activity is well behind that for the UK as a whole. Other UK universities, such as Queen's University Belfast and Cranfield University, are well-known in the UK and have built up a good reputation which reinforces its status in aerospace.

There is a danger that Scottish universities are overlooked if limited contact between the industry and academia remains. SE has a role to play in creating knowledge and link up these two sectors in a more effective way.

Scotland is also the main centre for shipbuilding and ship-repair in the UK. There are more than 125 companies employing over 5,500 people and sales are worth £530 million.

The shipbuilding industry faces similar barriers to research and innovation as the aerospace and defence industry. The recognition and communication between universities and the industry are not as effective as it could be. There are major opportunities in research, particularly on hull forms, balance treatment and ship stability, and by bringing industry and academia together, these opportunities could be further explored. SE again has a role to play in making and facilitating these linkages.

The key commercialisation barriers of research in the industry are limited information or knowledge, diverging internal operations and objectives, and confidentiality and international property rights. Whilst these issues exist in the aerospace, defence and shipbuilding they are not unique to these industries.

The limited knowledge makes the matching of university research and industry more difficult and as a result collaborations are less common. For example, employer survey results showed that 33% of aerospace companies in Scotland have links with universities, but 80% of companies had aspirations to work with them, particularly in relation to product development.²⁰

Furthermore, academia and industry often differ in their internal operations and objectives, which lead to different incentives, business models and timetables. University and industry collaborations and projects are also often hindered by the lack of clarity surrounding IP and confidentiality. There needs to be improved clarification and clear management of IP issues to facilitate further collaborations.

3.4.2 Key Academic Centres

There are three main areas of research strength within aerospace in Scotland:

- Research in sensors is mainly prevalent in around the Edinburgh area, with particular strengths at Heriot-Watt University.
- Space research is situated mainly around Dundee. University of Dundee has expertise in satellites, space wire systems and robots. **STAR-Dundee Ltd.**²¹ is a spin-out from the Space Systems Research Group of the University of Dundee. It is considered the most successful commercialisation activity of aerospace in Scotland, and the company has won several international contracts. Furthermore, the School of Informatics at University of Edinburgh has particular expertise in space, astrology and telescopes.
- Carbon composite engineering is relatively new to the industry and currently has a low industry pool but it is a growing area of aerospace.

Glasgow Research Partnership in Engineering (GRPE)²² is a research collaboration body between Universities of Glasgow, West of Scotland (previously Paisley), Glasgow Caledonian and Strathclyde. It focuses on research enhancement and commercialisation and its aim is to position the West of Scotland as a major world centre for Engineering. It is led by Universities of Glasgow and Strathclyde and Jim McDonald, Deputy Principal at Strathclyde, is Director of the partnership. GRPE is part of a major research pooling investment (ca £80m) by the Scottish Funding Council which brings together the Engineering Faculties of Universities in large-scale research collaborations. The focus of the research lies in:

- Electronic, Communication and Power Systems
- Environmental, Infrastructure and Transportation Engineering
- Mechanics of Materials, Structure and BioEngineering

Glasgow and the West of Scotland are recognised as a leading world centre for commercial ship management. The Department of **Naval Architecture and Marine Engineering**

²⁰ Aerospace - Industry Demand Statement

²¹ www.star-dundee.com

²² www.grpeng.ac.uk

(NAME)²³ is a joint department of the Universities of Glasgow and Strathclyde. They represent the principal research that is taking place, and is one of the premier providers of teaching and research in Naval Architecture and its related disciplines. Main research interests lie in ship stability and safety, marine hydrodynamics, marine structures, ocean engineering, marine engineering and emerging technologies.

Safety at Sea Ltd (SaS)²⁴ is a commercial enterprise operating within the premises and in partnership with the University of Strathclyde through the Ship Stability Research Centre. SaS is a spin-out consulting company of naval architects and marine engineers specialising in the stability, design and safe operation of ships and advanced marine vehicles.

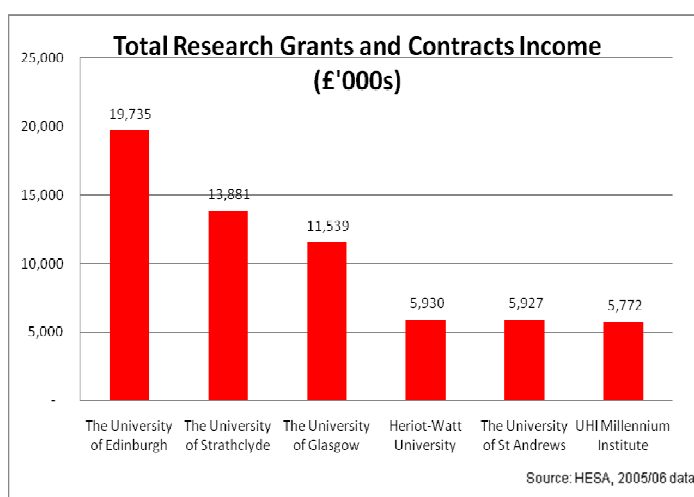
An initiative was set up in 2002, the **Scottish Sustainable Marine Environment Initiative** (SSMEI), and it aims to develop and evaluate approaches to the sustainable management of Scotland's marine resources. SSMEI produce recommendations to help shape future national policy on marine and coastal management and spatial planning.

The **Digital Design Studio at Glasgow School of Art**²⁵ is providing advanced 3D digital technologies of modelling and visualisation to the marine sector, and the Ministry of Defence have governed research into this area.

3.4.3 Total Research Income

Figure 3.17: Total Research Grants and Contracts Income

Total research grants and contracts income generated by Scottish universities, according to HESA 2005/06 data amounted to £66.4 million in the aerospace, defence and marine industry. This represents 17% of the total research grants and contracts income generated by Scottish universities across the 13 priority industries. Total research grants and contracts income in the industry is almost entirely (95%) accounted for by six universities,



with the Universities of Edinburgh and Strathclyde accounting for slightly over half.

The six universities are the University of Edinburgh (30%), the University of Strathclyde (21%), the University of Glasgow (17%), the Heriot-Watt University (9%), the University of St. Andrews (9%) and the UHI Millennium Institute (9%).

The data also suggests that research grants and contracts income from the industry are important for all of these five universities. The Universities of Strathclyde and the Heriot-Watt

²³ www.na-me.ac.uk

²⁴ www.safety-at-sea.co.uk

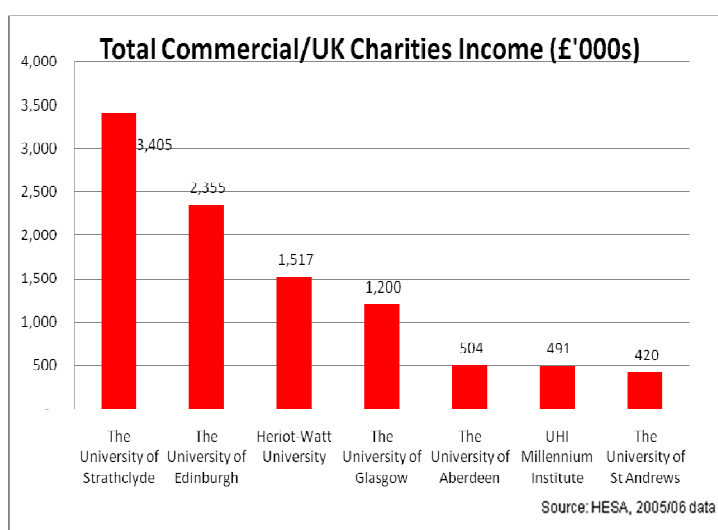
²⁵ www.gsa.ac.uk/ddc

are the most reliant on the research income from the industry which respectively accounts for as much as nearly half (48%) and 37% of their total research grants and contracts income.

Commercial Research Income in Aerospace, Defence and Maritime

A total commercial and UK charities income of £10.2 million was generated by Scottish universities in 2005/06. This represents 15% of the total research grants and contracts income generated by Scottish universities in the aerospace defence and maritime industry. In this regard, the University of Strathclyde (£3.4 million), the University of Edinburgh (£2.4 million) and the Heriot-Watt University (£1.5 million) are the biggest recipients of commercial and UK charities income accounting for 71% of the total commercial and UK charities income received by Scottish universities.

Figure 3.18: Total Commercial/UK Charities Income



3.4.4 Workforce

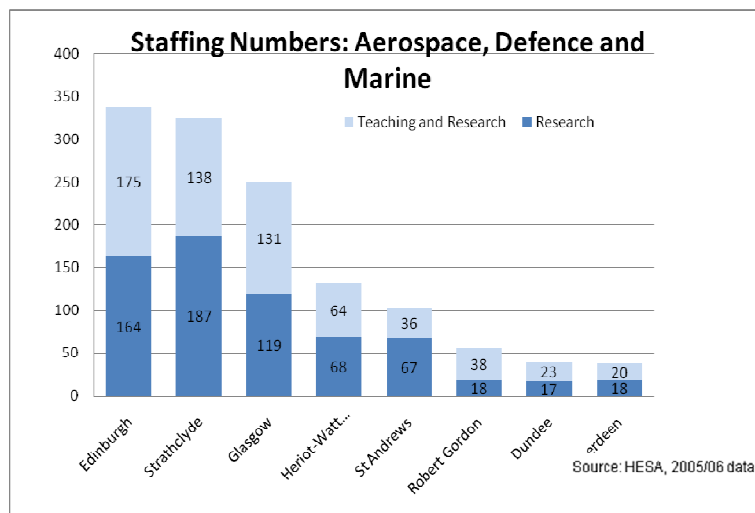
Staff

HESA 2005/06 data indicates that there were 1,355 academic professionals in the aerospace industry. The universities of Edinburgh (561) Strathclyde (479) and Glasgow (420) and are the main employers of academic professionals in the industry.

Research Staff

Of the total academic staff employed by Scottish universities in the industry, nearly two-thirds (60%) are employed either in exclusively academic research or academic research and teaching capacities. The split between academic professionals exclusively engaged in research and those engaged in both research and teaching is almost halfway with 573 involved exclusively in research and a further 553 involved in both research and teaching.

Figure 3.19: Staff Numbers



Students

According to HESA 2005/06 data, a total of 125 aerospace, defence and Marine related higher degrees were awarded by Scottish universities. This accounted for 9% of the total aerospace, defence and marine related higher degrees awarded by universities in the whole UK and at least double the number awarded by universities in Wales during the same period. The University of Strathclyde accounted for the majority of these awards.

Figure 3.20: Number of Higher Degrees Awarded 2005/06

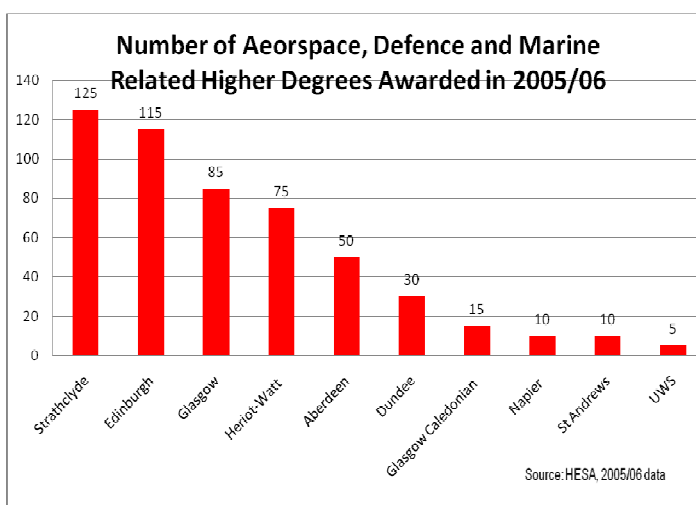


Table 3.6: High impact institutions – Aerospace, Defence and Marine

Institution	Income and Expenditure £ million			Workforce			Delivery		Rank
	Research Income	Commercial/ Charities Research Income	Staff FTE	Research Only Staff FTE	Teaching and Research FTE	Higher Degree Awards	PhD Awards	Most Common Publications and Citations	
Edinburgh	£19.7	£2.4	561	164	175	115		-	1
Strathclyde	£13.9	£3.4	479	187	138	125		-	2
Glasgow	£11.5	£1.2	420	119	131	85		-	3
Heriot-Watt	£5.9	£1.5	204	68	64	75		-	4
St Andrews	£5.9	£0.4	169	67	36	10		-	5
UHI	£5.8	£0.5	37	-	6
ALL Scotland	£66.4	£10.2	2,267	2,156	2,076	525		-	

3.5 Chemical Sciences

3.5.1 Overview

Chemical Sciences, prior to commencement of the study, was the last sector to emerge as a priority industry. Our understanding is that the sector has received very little strategic focus from SE and other development partners, but that its emergence as a PI has increased the emphasis upon it, with development of a united front between academia and industry under the banner **Chemical Sciences Scotland**²⁶. Chemical sciences are now recognised by SE as providing a source of high value-added activity within the economy as well as the underpinning science for most other sciences.

Chemical sciences has now been recognised as a priority industry for Scotland's economy because:

- Scotland contributes almost 10 per cent (i.e. around £3.4billion) of the UK output;
- the sector is Scotland's second biggest export earner, responsible for 8 per cent (£1.3billion) of manufacturing exports;
- it's one of Scotland's highest value industries, employing 13,500 skilled staff, many of them graduates with an average Gross Value Added (GVA) per employee of £76,300;
- around 70,000 jobs in Scotland are directly dependent upon the sector;
- Scotland's highly-rated universities (in both chemical science and engineering disciplines) produce around 1000 graduates per annum; and
- there are over 100 chemical companies in Scotland, with significant concentrations in the Forth Valley, Ayrshire, Renfrewshire, Fife and Dumfries and Galloway areas.

Chemical Sciences, in terms of contribution of GVA and in addressing the productivity gap, is therefore one of the highest value areas of the Scottish economy. Investment that impacts upon output from the sector can therefore have a particularly significant impact upon overall economic growth.

The sector team within SE have been working with the Scottish Government on improving the statistics for the sector which have traditionally worked to undervalue the sector in terms of its contribution to GDP. For example, INEOS is the 3rd largest company of its type in the World, is a highly valued employer in the Forth Valley and has 20% of its assets in Scotland. However, the data for INEOS are non-disclosable and hence this restricts reporting of the scale of the sector.

However, it is clear that Chemical Sciences is a global industry, with global players. The industry base is what drives commercialisation. Universities constitute a powerhouse to inform industry, but for Chemical Sciences, it is now emerging that the industry itself dictates what research is required. Notwithstanding this, it is recognised by SE that in Scotland we have a global university base and a global business base, but perversely we have poor linkages between universities and businesses in Scotland.

²⁶ <http://www.scottish-enterprise.com/css>

A lot of research and development is not classified as such in the chemical sciences sector, as there is a systematic failure to recognise innovation in the manufacturing process in terms of its R&D characteristics. In chemical sciences, innovation may produce entirely new, bespoke products for a client on a daily basis, but companies are known to regard this as part of the day-to-day running of plant, rather than recognising that they are constantly developing the range of products.

Despite these limitations, R&D expenditure in chemical sciences is high. SE estimates that R&D may constitute 0.6% of GDP on average across all sectors in Scotland, but equivalent in value to 1.1% of output within Chemical Sciences. The opportunity is described as being “*enormous for Scotland’s economy*”. However, a constraint on growing the sector and its contribution has been that there are obvious negatives too, as the public’s perception is of a “*dirty/polluting*” industry.

However, Scottish Enterprise is working through the implications for investment in research infrastructure and capacity. SE has an objective of ensuring that academia is *moiré* responsive to industry need and are seeking for industry to be able to engage with academia on a “one to one basis and not one to several” through identifying key nodes with which industry can collaborate, and encouraging a pooling of capabilities to present a coherent picture to industry.

3.5.2 Research Themes

The key research themes that will drive forward Scotland’s Chemical Sciences sector are as follows:

- Carbon reduction
- Biofuels
- Industrial biotechnology

Biofuels is considered to be of particular interest in that demand for conventional biofuels is driving wheat prices up by 36%, as well as renewable sugar sources and palm oil.

Second, third and fourth generation biofuels are the area that is causing particular excitement, in that in the event that it is possible to identify fuels that have a less significant knock-on effect on food prices, and it is possible to develop products and technologies to use them, then there could be a huge potential gain for Scotland.

Industrial biotechnology and renewable fuels are also key, because at the moment much of what the world manufactures is dependent upon chemicals and plastics. This research will investigate whether we still need to use oil in the future, or whether viable alternatives can be found. Essentially the research objective boiled down to whether inputs to the chemicals sector can be derived from more sustainable sources and the sector can move to a lower carbon hierarchy, through altering processes and raw materials required.

SE anticipates that in future there will be greater cross-boundary working between chemists, biologists and biotechnicians. It is envisaged that this will require taking a wider view and making use of Scotland's academic base. The University of Aberdeen and the University of Strathclyde are both well positioned to deliver this, due to involvement in areas such as carbon capture.

Other sectors for which there is close co-operation with Chemical Sciences include Aerospace and Textiles, both of which, to a degree, depend upon Chemical Sciences playing an enabling role in innovation. Similar relationships exist with Energy, Food and Drink, Forestry and Life Sciences.

3.5.3 Key Academic Centres

Chemical Sciences Scotland and SE have identified that there is actually a considerable quantity of research activity in Scotland. As an overview:

- University of Edinburgh is the perceived leader in terms of research
- University of St Andrews, University of Glasgow and University of Strathclyde are all very well regarded institutions developing specialist areas of research
- Glasgow Caledonian, Heriot-Watt and Napier are all active in terms of delivering research, as is University of Dundee, but the research within the latter is now merged into its School of Life Sciences.
- University of Aberdeen and University of Abertay are also regarded as important players, but the University of West of Scotland is mainly active in terms of teaching rather than research, with a very vocationally oriented chemical engineering course.

Edinburgh is the leading Scottish University for Chemistry and is perceived to be highly organised and well resourced. The School of Chemistry²⁷ at Edinburgh was rated 5* in the most recent Research Assessment Exercise (RAE2001). Key areas for research within the School include: the Chemistry/Biology interface, experimental and theoretical chemical physics, molecular synthetic chemistry, and materials chemistry. Research interactions exist with other disciplines such as Physics, Biology, Materials Science and Engineering.

University of St Andrews²⁸ is working with South African firm, SASOL, on developing clean coal technologies. SASOL staff are implanted into the university and in PhD scholarships. There have been spin-outs from St Andrews. Researchers at the University's School of Chemistry are also developing solid oxide fuel cell materials and collaborating with commercial partners such as: Tioxide, BG plc, Rolls Royce, Japan Storage Batteries and Nissan.

²⁷ <http://www.chem.ed.ac.uk/research/index.html>

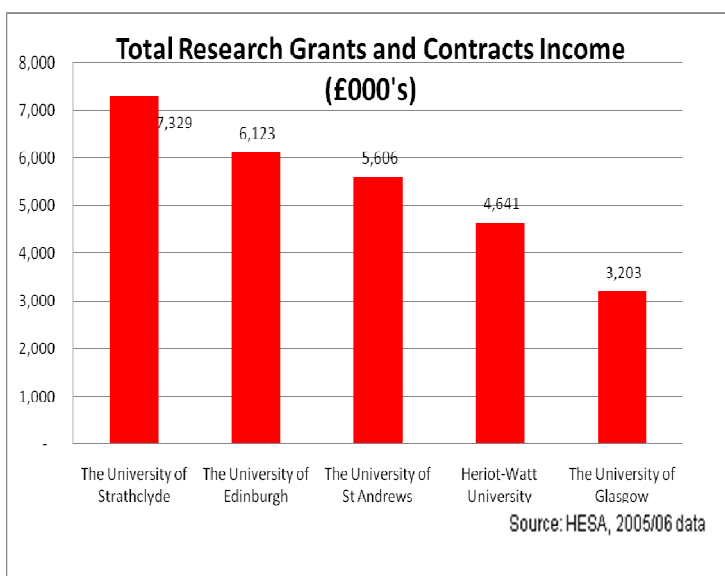
²⁸ <http://ch-www.st-andrews.ac.uk/allhighlights.html>

At the University of Glasgow, Professor David Jacobson is known to have strong links to ICI, and GSK, with many PhD students based in Glasgow. Professor Chris Gilmour is Chairman of SCOTCHEM and has aspirations for enhanced commercialisation. Glasgow's strengths include bio molecular chemistry²⁹, structure and materials (synthesis, characterisation, modelling, and application)³⁰ and synthesis of natural products³¹.

3.5.4 Total Research Income

Scottish universities generate £29.7 million in total research grants and contract incomes in the chemicals industry. Of this, 90% (£26.9 million) is generated by five universities namely the universities of Strathclyde (£7.3 million), Edinburgh (£6.1 million), St Andrews (£5.6 million), Heriot-Watt (£4.6 million) and Glasgow (£3.2 million). Of these five universities the universities of Heriot-Watt, St Andrews and Strathclyde are more reliant on research grant and contract income from this industry which respectively account for 31%, 20% and 26% of the individual university's total research grant and contract income.

Figure 3.21: Total Research Grants and Contracts Income

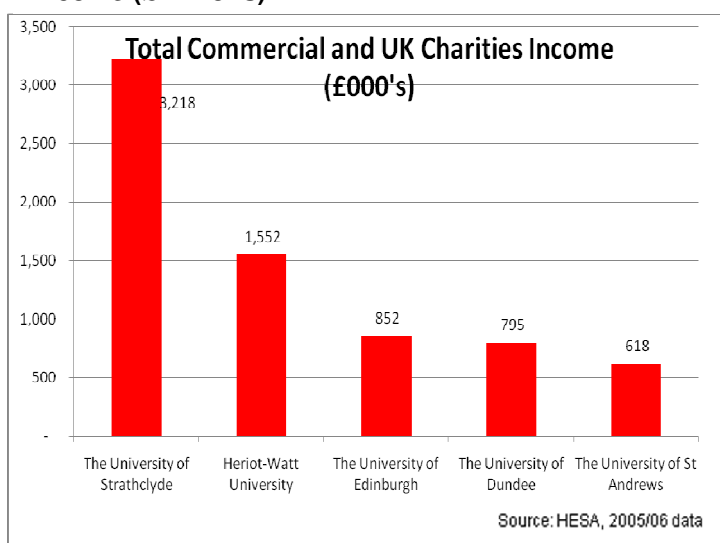


Commercial Research Income in Chemicals

Scottish universities generate £7.7 million in total commercial and UK charities income, 83% (£6.5 million) of which is generated by four universities. These are; the University of Strathclyde (3.2 million), the Heriot-Watt University (£1.5 million), the University of Edinburgh (£0.9 million) and the University of Dundee (£0.8 million).

The data also reveals that commercial and UK charities income provides a significant share of total research grant and contract income for these four universities. The chemicals industry accounts for 63% of the University of Dundee's total research grant and contract income and 44%, 33% and 13% for the universities of Strathclyde, Heriot-Watt, and

Figure 3.22: Total Commercial / UK Charities Income (£millions)



²⁹ <http://www.chem.gla.ac.uk/research/sections/BioMol/>

³⁰ <http://www.chem.gla.ac.uk/research/sections/StructMats/>

³¹ <http://www.chem.gla.ac.uk/research/sections/Synthesis/>

Edinburgh respectively.

Despite the University of St Andrews employing four times more academic professionals in the chemicals industry than the University of Dundee, the University of Dundee still generates 1.3 times more commercial and UK charities income.

3.5.5 Workforce

Staff

2005/06 HESA data indicates that that academic professionals employed by Scottish universities in the chemicals industry is around 3.1 percent (1,054) of the total number of academic professionals employed by Scottish universities.

Research Staff

Of the 1,054 employees of Scottish universities in the chemicals industry, 649 (62%) are employed either in research only or in both research and teaching capacities. Further analysis shows that 332 academic professionals are employed in exclusively research related work which may be of relevance to the sector.

Four universities employ 71% (466) of the total research staff in the sector. These are; the University of Strathclyde (171), University of Edinburgh (108), the Heriot-Watt University (97) and the University of St Andrews (90).

Students

The data available made it impossible to isolate PhD degrees from other Higher degrees (such as Masters). Therefore, we will here refer to the whole "Higher degrees" category, bearing in mind that PhD degrees probably make up less than half of this broad category.

In the 2005/06 academic year in Scotland, no less than 390 Higher degrees have been awarded in Chemical Sciences. Heriot-Watt University is by far the largest provider of Chemical Sciences Higher

Figure 3.23: Staff numbers

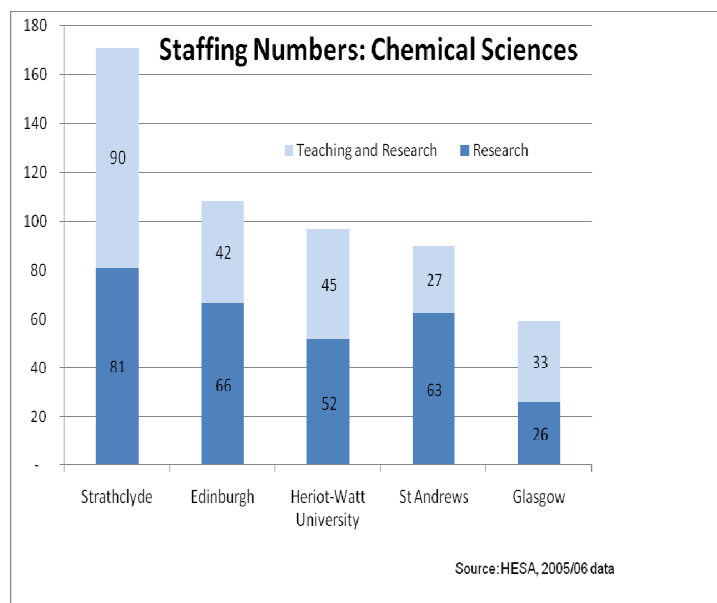
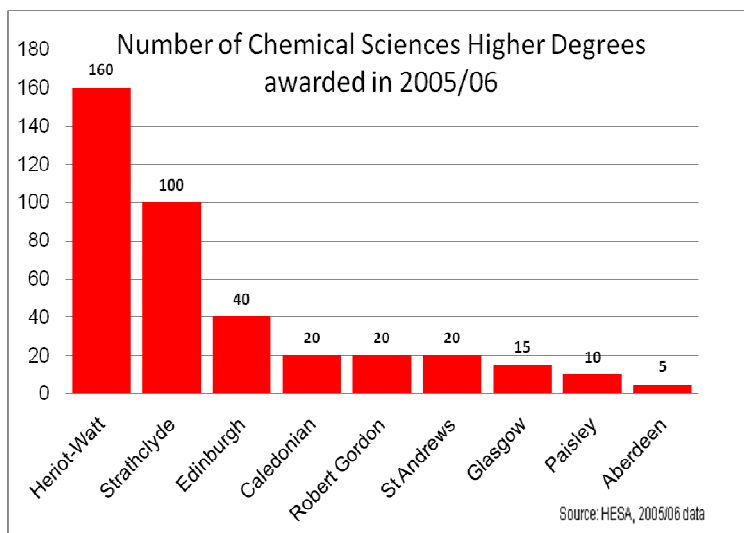


Figure 3.24: Number of Higher Degrees Awarded 2005/06



degrees, as it accounts for 40% of the total (160 degrees awarded). The University of Strathclyde is another key player in this field as it awarded 100 degrees in 2006, which represent over a quarter of the total amount of Chemical Sciences graduates.

These two institutions combined provide exactly two thirds of Scotland's chemical science related higher degrees, while other universities such as University of Edinburgh, Caledonian University or Glasgow University are more modest players (40, 20 and 15 degrees awarded, respectively).

One of the potential barriers to successful growth of R&D is the shortage of PhDs. SE Chemical Sciences team highlighted that workforce development has been neglected in the past, due to perceived downward spiral of the sector, aided by misleading statistics on the economic value and scale of the sector. One of the key drivers for improving the sector's visibility has been to address the recruitment difficulties faced in the industry³².

Encouraging signs are emerging of an increased trend towards studying chemistry at university, e.g. courses at University of St Andrews are thought to be significantly oversubscribed. University of Edinburgh and University of Glasgow are constrained in terms of SFC- funded undergraduate places, which has a knock-on effect in limiting the numbers of graduates progressing to study for a higher degree, such as a doctorate.

In response to a perceived shortage of PhDs, a groundbreaking new initiative, ScotCHEM (see below), Chemical Sciences Scotland (CSS) and the Scottish Funding Council (SFC) have announced³³ the creation of 31 new PhD studentships in chemistry to work on challenges and opportunities identified by Scotland's £3.5bn chemical sciences industry. SFC and the seven universities involved in ScotCHEM are investing £1.8 million over 3 years in this collaborative initiative. This partnership between universities and the chemicals industry is thought to provide a unique opportunity for chemistry graduates, who will split their time between university and industry placements, to understand the needs of industry. The partnership seeks to foster closer ties between Scotland's chemistry research community and its chemical industry.

3.5.6 Delivery

Chemical Sciences Scotland (CSS) have highlighted specific examples of research activity, such as the University of Strathclyde undertaking pioneering work on the development of *Leucovorin* as an anti-cancer drug. CSS group Scottish research capabilities as follows:

- **Materials chemistry** – University of Aberdeen, University of Edinburgh, Heriot Watt University and University of St Andrews.
- **Synthesis** – University of Edinburgh, Heriot Watt University (especially medicinally important compounds) and University of St Andrews.
- **Process technologies and optimisation** – Robert Gordon University, University of Edinburgh.
- **Catalysis** – University of Aberdeen and University of Glasgow.

³² SE Chemical Sciences team have also highlighted that a key role is played by FE colleges in providing a conveyor belt of vocational training of employees for the sector.

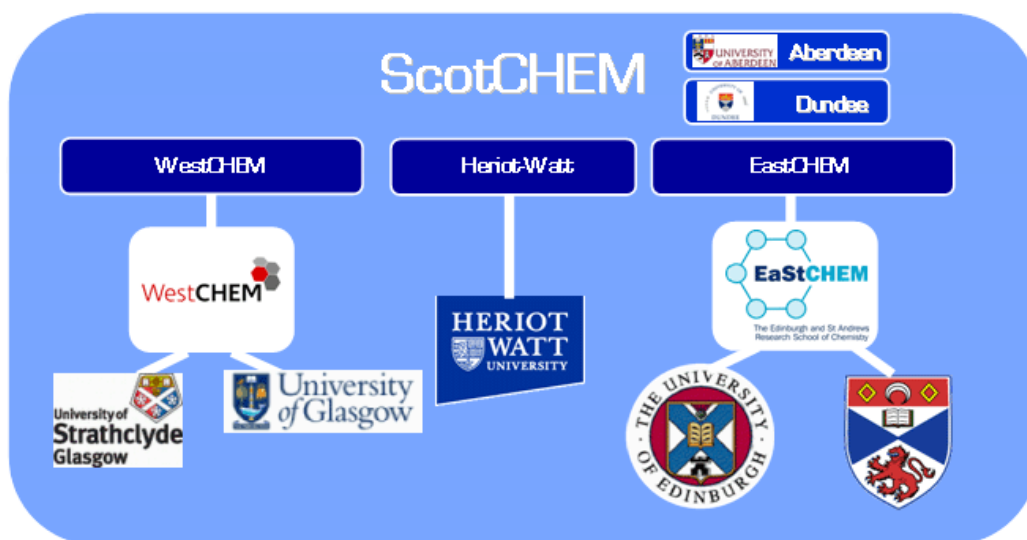
³³ Announced on 22 September 2008: see http://www.sfc.ac.uk/news/scotchchem_phds_press_release_220908.pdf for further details.

- **Environmental speciation and remediation** – University of Aberdeen
- **Medicinal chemistry** – University of Aberdeen

There is a single key research pooling initiative, called ScotCHEM³⁴, which is driving the sector in Scotland. It is a strategic initiative to bring together the major players in research in chemical sciences in Scotland and “represents a community of 190 academic staff, 240 postdoctoral researchers, and 480 postgraduate research students”, with the aim to generate enhanced critical mass and joint access to resources. This has effectively two teams – EastCHEM (Edinburgh and St Andrews)³⁵ and WestCHEM (Glasgow and Strathclyde)³⁶, although Heriot-Watt, Aberdeen and Dundee universities are also involved.

The Scottish Funding Council has pumped money (£9 million) into drawing new chairs of Chemistry to Scotland, with the Universities themselves having topped this up to £23 million over a four year period. This has delivered a total of 14 new chairs to-date. The Sector is also moving onto, in effect, creation of a ‘ScotCHEM 2’, which will aim to support commercialisation and has clear industry involvement.

SE may seek to take an account management approach to all Scottish chemistry departments, rather than to university as a whole, i.e. need to meet regularly to discuss conditions for expansion of departments/ future viability. Academic research within the universities has been relatively invisible and most University Relationship Managers would, reputedly, not be able to identify who the head of the university chemistry department was. The Chemical Sciences team recognise that this needs to change.



Source: ScotCHEM

³⁴ Within the overall ScotCHEM grouping are two regional, funded “pairing” initiatives; WestCHEM (Glasgow and Strathclyde) and EastCHEM (Edinburgh and St Andrews). A separate Heriot-Watt initiative is also funded, while Dundee and Aberdeen will benefit from the development of enhanced research networks and improved access to major research resources. The three funded initiatives within ScotCHEM are being supported by major investments from the Scottish Funding Council and in part by the Office of Science and Technology. More information at: <http://www.scotchem.ac.uk/>

³⁵ <http://www.eastchem.ac.uk/>

³⁶ <http://www.westchem.ac.uk/>

3.5.7 Commercialisation

There has been a clear policy of encouragement to innovate through collaboration. The sector's key employers collaborate in high-level, confidential dialogue regarding the sector's research priorities. Effectively they determine among their peers what the key areas of research interest are for the sector, with a clear bias towards areas with a potential commercial outcome. Once agreed, this is then communicated to the wider audience, including academia. The principle has and continues to be to formulate ideas up front and then work out a package to deliver this thereafter.

A reported difficulty for the sector is that universities and commercial concerns can "talk in a different language" to each other, while timescales for delivery can often be at odds with industry requirements.

Therefore scope is available for academics and businesses to work better together to set out the research objectives, the research outcomes sought and timescales associated with delivery. There may be a need for external validation to ensure that the university commissioned has the resources available to deliver, given results are needed within fixed deadlines.

Intellectual property rights are also a key area of concern, with some firms having been exasperated in working with universities where there have been conflicts over IPR and a lack of institutions willing to negotiate over IPR. In one example, it has taken more than 2 years to negotiate and, as a direct consequence, the research had still not started. In another case the research had been completed for 18 months, but the university and the client had still not agreed the financial returns for the university.

In respect of research in areas such as biofuels there may need to be realism in that it would probably be necessary to hold the knowledge in Scotland, and build upon it, while selling on that expertise to those who can exploit it.

Chemical Sciences have only been accepted as an eligible sector by POC since late 2006 and have had to push hard for this status. Between February 2007 and October 2007, Chemical Sciences projects had constituted a total of 10 applications, with 4 funded Proof of Concept projects. All of the projects have seen sector specialists working with academia and all 4 successful projects have set out clearly that what was being undertaken would have a commercial objective. In fact Chemical Sciences is well placed to exploit PoC funding in future, for this reason.

Table 3.7: High impact institutions – Chemical Sciences

Institution	Income and Expenditure £ million			Research Only Staff FTE	Teaching and Research FTE	Workforce		Delivery	Rank
	Research Income	Commercial/ Charities Research Income	Staff FTE			Higher Degree Awards	PhD Awards	Most Common Publications and Citations	
Strathclyde	£7.3	£3.2	292	81	90	100	..	-	1
Edinburgh	£6.1	£0.9	156	66	42	40	..	-	2
St Andrews	£5.6	£0.6	121	63	27	20	..	-	3
Heriot-Watt	£4.6	£1.6	147	52	45	160	..	-	4
Glasgow	£3.2	£0.1	94	26	33	15	..	-	5
Dundee	£1.3	£0.8	29	13	9	0	..	-	6
ALL Scotland	£78.0	£12.0	1,054	332	317	390		-	

3.6 Financial Services

3.6.1 Overview

The financial services sector is a major contributor to the economy of Scotland and it is also a major source of employment. It accounts for almost 1 in 10 jobs in Scotland, employing 108,000 people directly and almost 90,000 in support and related industries. Finance services has been one of the fastest growing sectors in the Scottish economy. Since 1998 the industry has grown by 96 per cent in Scotland, and over 60 per cent since 2000, compared to a growth rate of 14 per cent for the Scottish economy as a whole. In 2006 the industry's exports were estimated to be over £1.1 billion, and it currently contributes over £7 billion to Scottish GDP.³⁷

Scotland is the second largest financial region in the UK next to London. It is one of Europe's leading financial services centres and a location for a wide range of international activities. The financial sector in Scotland has particular strengths in:

- Banking;
- General Insurance, Life Assurance and Pensions;
- Investments Managements; and
- Asset Servicing (investment operations).

Historically, there has been little or no take up of SE support initiatives and activity and there is a low level of collaboration between the Financial Services industry and the Universities in Scotland. An effort to increase awareness and stimulate support for innovation has the potential to reverse this trend. There may, for example, be collaborative opportunities to work with supply companies in other sector areas such as electronic markets and life sciences (for example, bio-security).

The industry strategy has been developed by the industry in partnership with the public sector (Scottish Enterprise and the Scottish Government), trade unions and higher education. Its overarching objective is to create:

“An innovative, competitive and thriving international financial services industry in Scotland underpinned by world-class infrastructure and universally recognised as a leader on the world stage.”

The Financial Services Advisory Board (FiSAB) is the custodian of this strategy. The Scottish Government has signalled its strong support for this initiative and First Minister Alex Salmond has agreed to chair FiSAB. Members are senior industry representatives from across various sub sectors of the industry together with trade union and university representatives.

Financial Services Implementation Group (FiSIG) oversees the strategy and is responsible for its delivery. This plan sets out the actions, aims and measurements of success under the following three main pillars:

- **People and Skills** – skills and labour market development, raising the appeal of the industry as a career choice, financial education in schools;

³⁷ Statistics from Scottish Enterprise and Scottish Government.

- **Profile** – developing the proposition for the industry in Scotland, raising the profile of Scotland as an international centre, attract value added FDI, engage with key stakeholders such as FSA, EU, UKT&I and HM Treasury; and
- **Infrastructure** – transport and connectivity, communications, city collaboration, support for innovation, university collaboration and supply chain development.

There is a commitment to innovate across these three pillars, recognising that innovation is an integral component of a successful and competitive financial services industry. One of the four delivery sub-groups is the **University Collaboration group**. It was created six months ago and acts as a central advisory group for the industry and the universities. Its focus is to create and encourage closer engagement between academia and industry.

3.6.2 Key Academic Centres

Strong partners of the University Collaboration group are the Universities of Glasgow, Edinburgh, Stirling and Heriot-Watt. These universities are key in terms of the current research that is undertaken. Their specialism is spread across different themes, for example, Heriot-Watt is a key player in actuarial research, Stirling and Glasgow Caledonian in risk and management and Glasgow in business finance. Furthermore, the School of Informatics at University of Edinburgh has a direct impact on the financial services sector with leading edge activity taking place in voice recognition and information analysis.

The University Collaboration group acts as a unifying body to stimulate research, and it gathers and collates university collaboration information to provide a Higher Education overview. The aim is to scope out what a **centre of excellence** should consist of, for example research commissioning capabilities. In order to do so the current pockets of excellence are being identified.

The industry is highly innovative and it is a big consumer of technology. There is a renewed interest in development and innovation, and recently some major financial service players have introduced technology innovation responsibilities and units which oversee the fast-moving product innovation. Furthermore, research is undertaken internally by businesses, for example the new Business School at RBS's headquarters in Edinburgh. The School sources academic expertise from across the world to teach, but often academia in Scotland is overlooked.

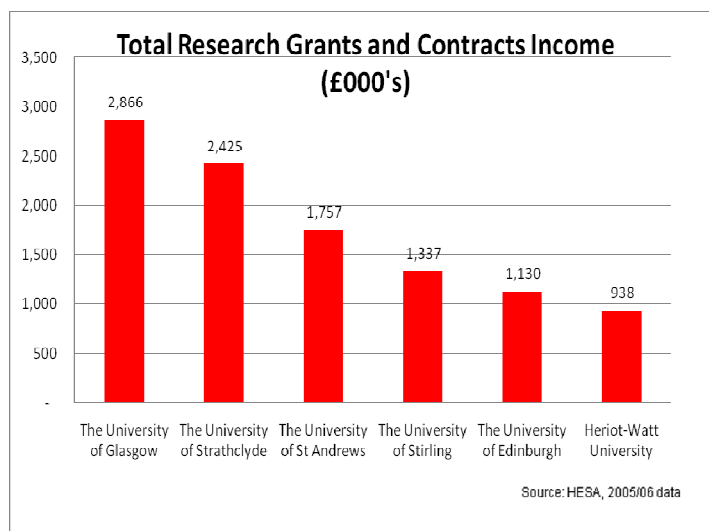
Activities of commercialisation on the other hand are limited, and despite good relationships between the industry and universities the collaboration does not go beyond that. An explanation to the commercialisation barriers is **limited knowledge**. The industry is often unaware of the existing resources within the universities, and is unaware of what is available locally. There is a **need for greater visibility, transparency, engagement and understanding** between the academic sector and industry.

3.6.3 Total Research Income

Scottish universities generate a total of £12.8 million research income in the financial services. Of this amount, the University of Glasgow (£2.9 million), University of Strathclyde (£2.4 million), University of St Andrews (£1.8 million), University of Stirling (£1.3 million) and the University of Edinburgh (£1.1 million) are the top five research income generating universities in the industry. They account for 75% of the total research income generated by Scottish universities in the industry.

Of the five top income earners, only the University of Stirling is relatively dependent on research income from the financial services industry which accounts for 14% of the total university's research income. The other four are far less dependent on research income from the industry which accounts for less than a tenth of the individual universities' total research income.

Figure 3.25: Total Research Grants and Contracts Income



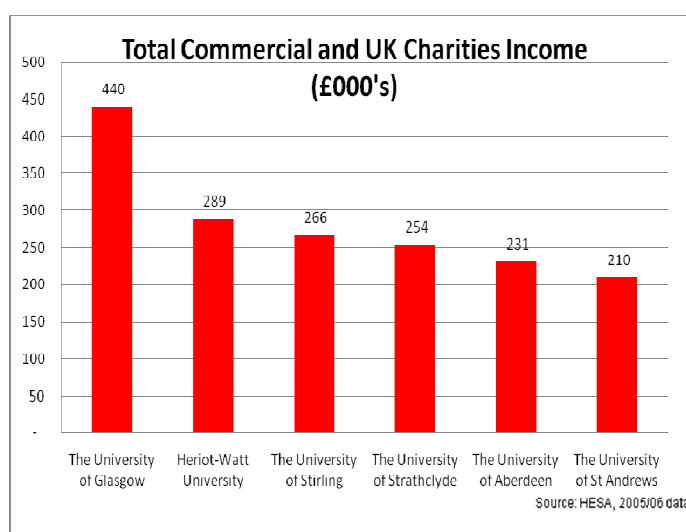
Commercial Research Income in Financial Services

The total commercial/UK charities income generated in the financial services industry is £2.1 million. The university of Glasgow (£0.4 million), university of Heriot-Watt (£0.3 million), university of Stirling (£0.3 million), university of Strathclyde £0.3 million and university of Aberdeen (£0.2 million) are the earners of commercial and UK charities income in the industry.

The data reveals that whilst not amongst the top 5 total research income earners in the industry, the universities of Heriot-Watt and Aberdeen are top commercial

income earners. Of interest is that the University of Aberdeen, with less than half (53) the number of academic professionals the University of Edinburgh (114) has in either research or research and teaching work in the industry is able to generate nearly twice as much commercial research income.

Figure 3.26: Total Commercial and UK Charities Income



3.6.4 Workforce

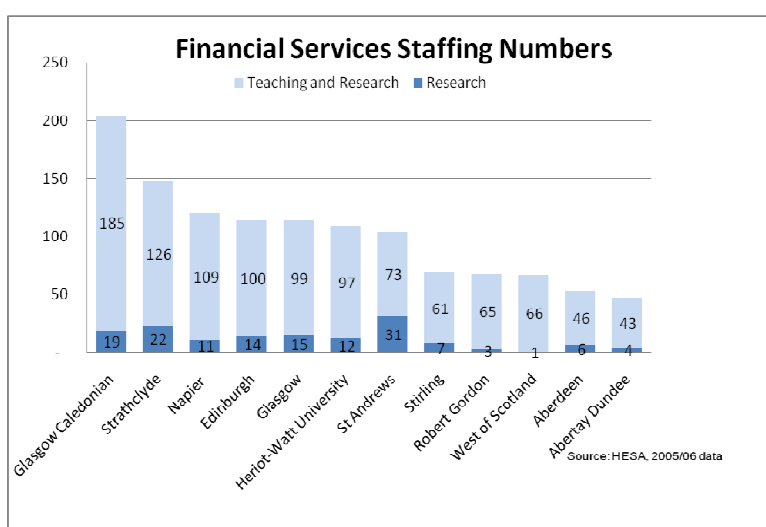
Staff

Scottish universities employ 2,004 academic professionals in the financial services industry making the industry the fourth largest employer of academic professionals of the 13 priority industries.

Research Staff

HESA 2005/06 data reveals that 64% (1,273) of the total academic professionals employed by Scottish universities in the financial services industry are engaged in either research exclusively, or research and teaching. A closer analysis reveals that only 12% (153) are exclusively employed for research.

Figure 3.27: Staff Numbers



The Glasgow Caledonian University (204), University of Strathclyde (148), University of Napier (120), University of Edinburgh (114) and Glasgow University (114) have the biggest number of academic professionals engaged in research related work. The Universities of Strathclyde (22) and St Andrews (31) have the highest number of academic professionals engaged exclusively in research.

The Queen Margaret University (21), University of Dundee (37), University of Abertay Dundee (47) and University of Aberdeen (53) employs the least number of academic professionals engaged in research related work in the financial services industry.

Students

Financial studies represent a very broad academic field, and include fifteen different HESA headings, although Business and Management studies account for half of the total. The total number of higher degrees related to financial studies awarded in Scotland in 2005/06 reached almost 3,000. Only 125 of them were PhD degrees.

The University of Strathclyde represent the bulk of the higher degrees delivered in 2006 with 20% of the total, followed by the Herriot-Watt, Stirling, Robert Gordon, Edinburgh and Glasgow universities, which all awarded between 250 and 350 higher degrees in financial studies in 2006.

Figure 3.28: Number Higher Degrees Awarded

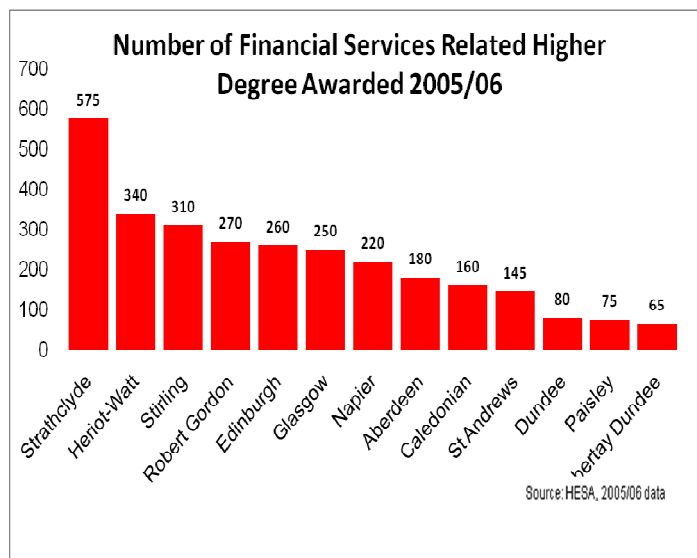


Table 3.8: High impact institutions – Financial Services

Institution	Income and Expenditure £ million					Workforce		Delivery	Rank
	Research Income	Commercial/ Charities Research Income	Staff FTE	Research Only Staff FTE	Teaching and Research FTE	Higher Degree Awards	PhD Awards	Most Common Publications and Citations	
Glasgow	£2.9	£0.4	183	15	99	250	..	-	1
Strathclyde	£2.4	£0.3	268	22	126	575	..	-	2
St Andrews	£1.8	£0.2	135	31	73	145	..	-	3
Stirling	£1.3	£0.3	121	7	61	310	..	-	4
Edinburgh	£1.1	£0.1	169	14	100	260	..	-	5
Heriot-Watt	£0.9	£0.3	183	12	97	340	..	-	6
ALL Scotland	£12.8	£2.1	2,004	153	1,121	2,950	125	-	

3.7 Food and Drink

3.7.1 Overview

Research by Scottish Enterprise shows Scotland employs 122,000 people in the food and drink processing sector and its associated supply chain, generating nearly £8 billion in sales. A further £2 billion comes from agriculture, aquaculture and fishing.

Food and drink is one of the largest employers within Scottish manufacturing and accounts for more than a quarter of manufacturing exports (25.2% in 2007, Index of Manufactured Exports). Scottish Enterprise estimates that the industry exported £3.57 billion of food and drink products in 2005.

The Scotland Food & Drink Business Plan (2007-2010) outlines a vision for a sustainable industry that is market-led and internationally competitive. Scotland has an ambition to be internationally known as the “land of food and drink” generates £10 billion a year from food and drink processing by 2017. A key driver of growth will be better anticipating market and consumer trends and developing innovative products and services.

A number of barriers for growth facing the food and drink industry were identified by the enterprise networks which are related to commercial research. The business plan cites a lack of understanding among companies of the extent to which investment contributes to the performance of their business. This results in low rates of investment into research.

Colleges and Universities allocate funding to meet policy and strategic priorities that do not necessarily respond to markets. Universities may, for example, allocate funding to maximise performance according to the Research Assessment Exercise (RAE). Also, institutions may not be well placed to deliver market-facing outcomes involving team working and collaboration across institutions.

A significant barrier to research involves Scottish companies under investing when they cannot recoup the benefits of research within their own company. Investment in research is likely to provide benefits to other food and drink companies, both in Scotland and elsewhere. As newly developed innovation and development spreads throughout the industry, the commercial returns to the original innovator will be reduced.

3.7.2 Key Academic Centres

The overall level of commercial research is small compared to other Scottish priority industries, particularly considering the large size of the Scottish food and drink industry. The Scottish Agricultural College (SAC) dominates both overall research income and commercial research income. The SAC supports the development of land-based industries and communities through specialist research.

The work of SAC has an emphasis on agriculture and related sciences including food chain quality and safety. Their research division has 230 staff, including more than 100 research scientists and the SAC spends more than £13 million each year on research.

Other areas of commercial research activity include the UHI Millennium Institute and the University of Aberdeen. Research within the UHI Millennium Institute is undertaken across a number of academic partners. Orkney College hosts the Agronomy Institute providing a crop based R&D facility for the Highlands and Islands and the North Atlantic Fisheries College (NAFC) provides fisheries training combined with applied research.

University of Aberdeen hosts the Applied Food Microbiology Group within the Institute of Medical Sciences providing food pathogen and hygiene testing services to food companies. Also at the University of Aberdeen, the college of life sciences and medicine include agriculture, plant and soil science.

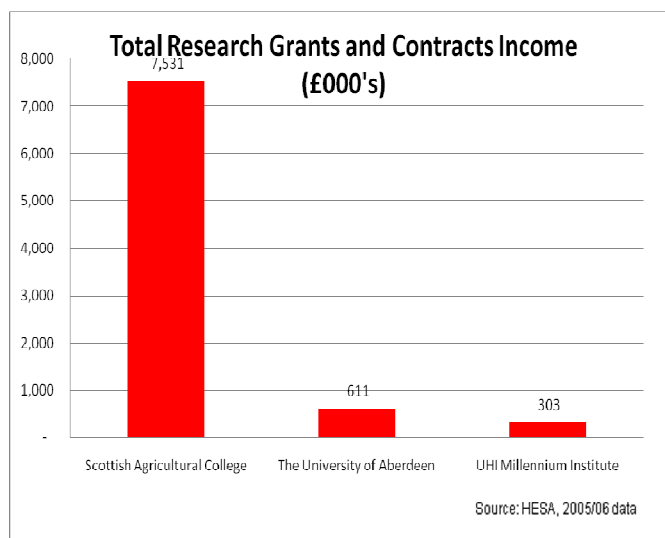
A major investment will be made between the public sector and industry in establishing an innovation centre for Scotland. This will identify and develop commercial opportunities through combining food research and marketing. It will enable industry to exploit health, wellbeing and environmental potential, and support initiatives which encourage adding value to primary produce.

It is envisaged through the innovation centre and other approaches, stronger links between industry and research will be realised. The centre will also seek to address the barriers to commercial research outlined above, for example by helping to influence the research organisations in Scotland.

3.7.3 Total Research Income

HESA 2005/06 statistics indicate that the Scottish universities generate £8.5 million in research income in the food and drink industry. The Scottish Agricultural College heavily dominates the industry accounting for 88% (£7.5 million) of the total research income generated by Scottish universities in the industry. The next biggest university in terms of research income generation in the sector is the University of Aberdeen (£0.6 million) which generates twelve times **less** income than the Scottish Agricultural College and then the UHI Millennium Institute (£0.3 million).

Figure 3.29: Total Research Grants and Contracts Income

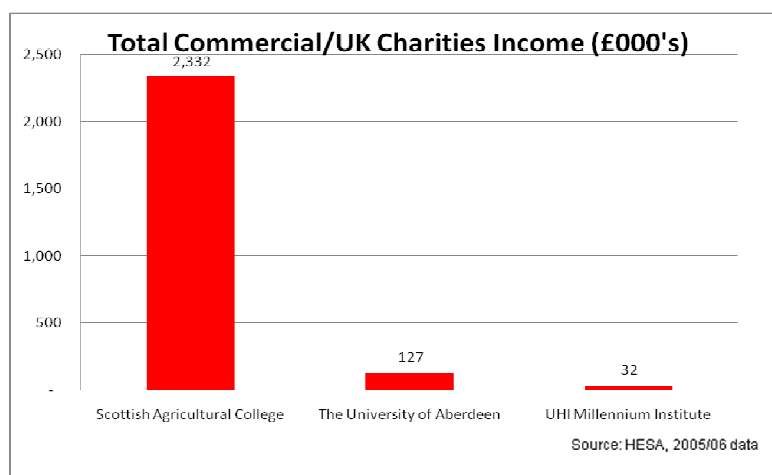


The relative weakness of the industry in the field of research is reflected in that research income generated by Scottish universities in the industry accounts for only 2% of the total research income generated by Scottish universities across all the 13 priority industries.

*Commercial Research
Income in Food and Drink*

The Scottish Agricultural College accounts for almost all (93%) of the total commercial and UK charities income. Data suggests that Scottish universities are not very reliant on commercial and/or UK charities income as only 30% (£2.5 million) of the total £8.5 million research income generated by the Scottish universities is generated from commercial and UK charities income.

Figure 3.30: Total Commercial and UK Charities Income



3.7.4 Workforce

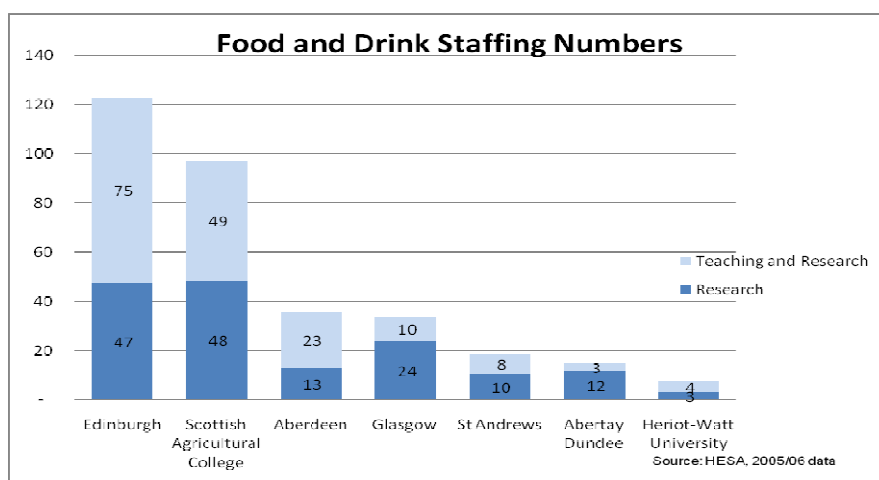
Staff

HESA 2005/06 data reveals that Scottish universities employ a substantial amount of academic professionals in the food and drink industry. Of the 13 priority industries, the food and drink is the seventh biggest employer amongst Scottish universities. Despite generating research income three times less, Scottish universities employ slightly more academic professionals in the food and drink (1,352) than in the chemical science industry (1,054).

Research Staff

Scottish universities employ 340 academic professionals in research related work in the food and drink industry. University of Edinburgh (123), the Scottish Agricultural College (97) and University of Aberdeen (35) are the major employers of academics in food and drink research. These institutions employ 75% of the total staff employed by Scottish universities in research related work in the industry.

Figure 3.31: Staff Numbers

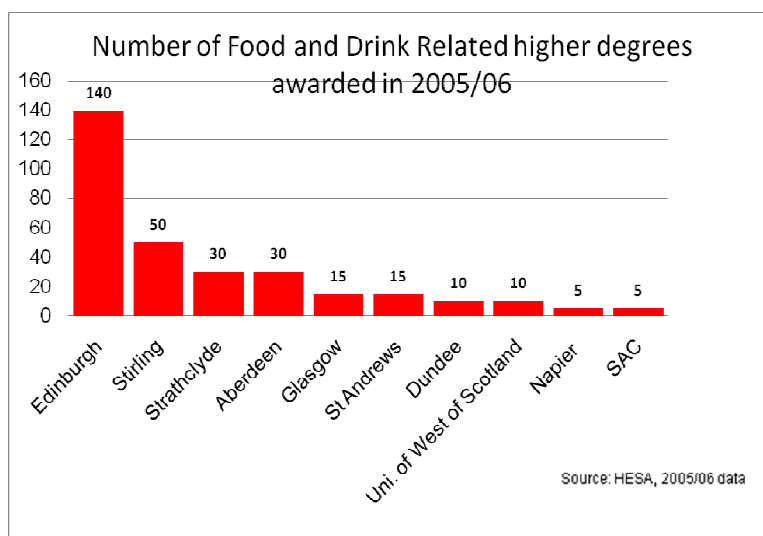


Students

On top of food, beverage and agricultural studies, the broad “Food and Drink” academic field also includes ocean, other agricultural and related sciences and environmental sciences.

310 higher degrees in food and drink related fields were awarded in Scotland in 2006, among which 35 were PhD degrees. Almost half of this total (45%) was delivered by the University of Edinburgh alone. Stirling, Strathclyde and Aberdeen, with a combined 110 degrees awarded in 2006 (1/3 of total) also play a key role in the field, while other universities are only marginally represented in this industry.

Figure 3.32: Number of Higher Degrees Awarded



3.8 Forest Industries

3.8.1 Overview

Activities of the forest industry in Scotland include planting, managing and harvesting of forests, as well as downstream activities such as sawmilling, producing pulp, paper and board, and manufacturing of higher value goods. Most of the timber resource is found in Dumfries and Galloway, the Borders, Tayside, Forth Valley, Argyll, Grampian and the Highlands and Islands.

Scotland accounts for 60 per cent of the British conifer harvest and 42 per cent of British lumber production. New markets are developing for biomass energy and a biomass power generation projects are up and running using sawmill residues in the Highlands and Islands.

One of the intended outcomes for the industry is to have competitive and innovative businesses contributing to the growth of the Scottish economy. Within this the key objectives are:

- Develop a more efficient and competitive timber supply chain;
- Facilitate the development of markets for forest products;
- Facilitate rural business diversification and development; and
- Increase the contribution that forestry makes to tourism.

3.8.2 Key Academic Centres

The main forestry research in Scotland is associated with the Strategic Integrated Research in Timber (SIRT)³⁸ project. SIRT is a collaborative project between the Centre for Timber Engineering at Napier University, the Department of Analytical and Environmental Chemistry at the University of Glasgow and the Silviculture and Timber Properties Group at Forest Research.

The primary focus of the SIRT project is to identify the extent and key causes of variation in the wood properties of local spruce (Sitka), which affects its use as a structural timber. The project currently has four key studies underway which are looking at different factors which are known to affect wood properties. These are genetics, initial spacing, environment, and rotation length.

Forestry Research, which is the research agency of the Forestry Commission, has in collaboration with Scottish Enterprise developed research programmes include conifer breeding and timber properties. The Northern Research Station in Roslin is one of the two main research stations in the UK, the other being at Alice Holt in Surrey. The research is focused on coniferous silviculture, tree improvement, woodland ecology, and the control of pests and diseases. Current programmes include research into biodiversity, ecological site classification, planting stock quality and windthrow.

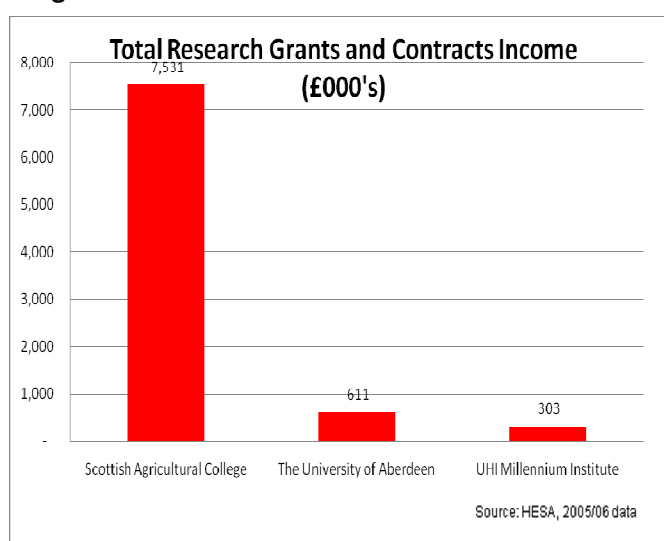
³⁸ www.cte.napier.ac.uk/SIRT/

To some extent partnership working between academia and industry is a new concept in Scotland, while this has been apparent for some time in Canada and Sweden for example. Forestry is considered a marginal industry and funding is the ultimate barrier for R&D. The aim however is to extend and improve links between academia and industry, and the Centre for Timber Engineering at Napier University is an example of partnership working.

3.8.3 Total Research Income

HESA 2005/06 statistics indicate that the Scottish universities generate £8.5 million in research income in forest industries. The Scottish Agricultural College heavily dominates the industry accounting for 88% (£7.5 million) of the total research income generated by Scottish universities in the food and drink industry. The next biggest university in terms of research income generation in the industry is the University of Aberdeen (£0.6 million) which generates twelve times **less** income than the Scottish Agricultural College and then the UHI Millennium Institute (£0.3 million).

Figure 3.33: Total Research Grants and Contracts Income

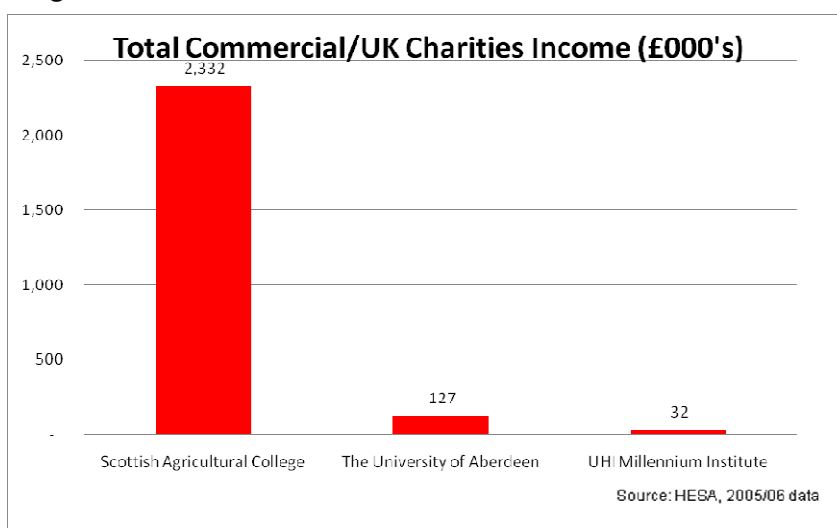


The relative insignificance of the industry in the field of research is reflected in that research income generated by Scottish universities accounts for only 2% of the total research income generated by Scottish universities across all the 13 priority industries.

Commercial Research Income in Forest Industries

The Scottish Agricultural College accounts for almost all (93%) of the total commercial and UK charities income. Data suggests that the sector is not very reliant on commercial and/or UK charities income as only 30% (£2.5 million) of the total £8.5 million research income generated by the Scottish universities is generated from commercial and UK charities income.

Figure 3.34: Total Commercial/UK Charities Income

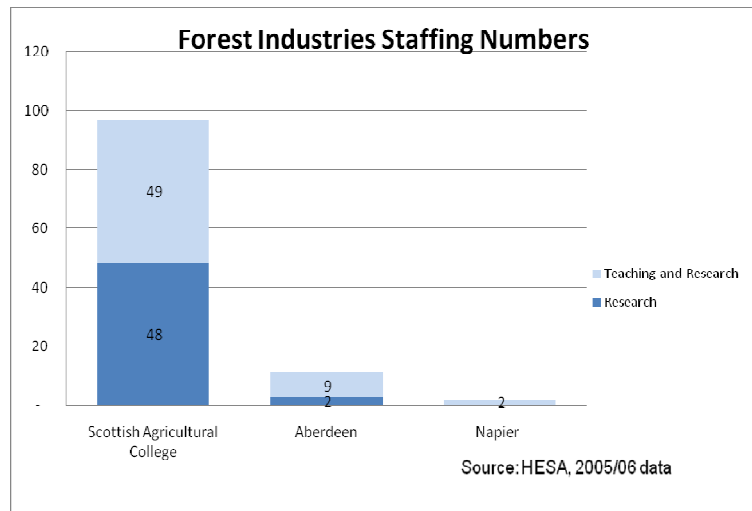


3.8.4 Workforce

Staff

HESA 2005/06 data indicates that a total of 861 academic were employed in Scottish universities, 95% (817) of whom are employed by the Scottish Agricultural College. Of this total, 20% (110) are employed in either research only or research and teaching capacities. The Scottish Agricultural College employs 80% (97) of all academic professionals employed by Scottish universities who are involved in forest industries research.

Figure 3.35: Staff Numbers



Students

According to available HESA data, only 35 higher degrees were awarded in the industry in the whole of the UK. Thirty of these awards were given at Welsh universities, 5 from Scottish universities and none from universities in England. All of the 5 were awarded by the University of Aberdeen in Scotland.

3.9 Construction

3.9.1 Overview

In early 2007 over 160,000 people worked in the industry in Scotland and more than 40,000 businesses were involved in the sector. In 2005 turnover was around £13.4 billion, and output in the industry has grown over the last eight years at an average rate of 3% per year.

The core industry of construction is demand driven and for core activities innovation is not generally encouraged. The green agenda is currently driving R&D through legislation and spurring businesses to seek strategic relationships with partners, including universities. However, the industry is highly price sensitive and R&D remains relatively low.

The Scottish Construction Centre (SCC)³⁹ has been created to promote innovation and excellence in Scotland's construction industry. Various initiatives and projects have been developed to assist with the implementation of current or proposed Government policy, and to support the industry in meeting targets with respect to innovation, sustainability and carbon reduction. For example:

- Members of the SCC consortium are currently involved in developing a number of research initiatives to investigate flood preparedness, protection and post-flood repair.
- The BRE Innovation Park in East Kilbride features a number of demonstration properties showcasing Modern Methods of Construction, near zero-carbon homes, and over 200 different innovative and emerging technologies.
- BRE Scotland and the University of Strathclyde are working together with a cross-industry consortium on an internet-enabled buildings project. The project involves trialling the use of internet-enabled technology at construction sites, innovative housing and social housing and assessing how well it can satisfy the needs of the technology-users.

3.9.2 Key Academic Centres

There is considerably cross-over in research between construction related research and that of chemicals, engineering and energy. However, the research also tends to be, by its very nature, highly applied and industrially relevant. Often work is undertaken with input and support by industry.

The BRE, the BRE Trust and a group of UK universities have launched a new strategic research and development partnership that will create new Centres of Excellence in four subject areas, two of which are in Scotland. These specialisms are Fire Safety Engineering at the University of Edinburgh and Energy Utilisation Research at the University of Strathclyde.

The idea of these new centres is to develop new research capabilities and for the partners to work together to improve the flow of knowledge between academia and industry. The BRE

³⁹ www.scocon.org/index.jsp

Centre for Fire Safety Engineering has a team of over twenty researchers working on a variety of research projects, for example fundamental combustion processes and application of fire safety engineering.

The School of the Built Environment at Heriot-Watt University is one of only seven Built Environment Schools in the UK, and the only one in Scotland to receive an RAE Grade 5 rating in both 1996 and 2001. The fields of research include thermal transmission, drainage and materials testing, modelling of large scale structural, geotechnical and hydrodynamic behaviour, and corrosion monitoring. The School has a relatively high level of industry-orientated activities with industrial funding and external collaboration.

Research initiatives include:

- The Flood Risk Management Research Consortium, which brings together agencies and academic institutions to generate new scientific and innovative measures to predict and manage the risk of flooding
- Led by Professor Phil Banfill, research is in progress into chemical and rheological properties of cement-based materials, sustainable materials and methods in construction technology, and the technology and conservation of historic buildings. Other significant interests are in the migration of moisture within buildings and the value engineering approach to sustainable construction.

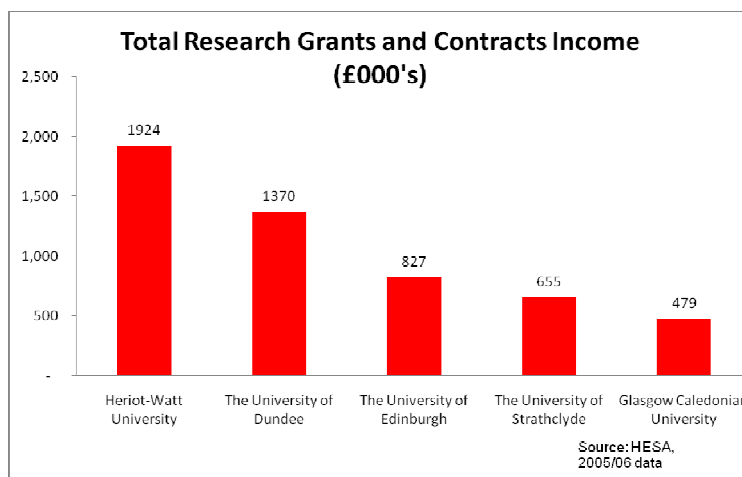
Concrete Technology Unit (CTU) is part of the Concrete and Construction research sub-group at University of Dundee. It conducts research in cement/concrete science, concrete technology and construction, as well as outreach, CPD and technology transfer activities. It aims to assist the concrete construction industry in becoming more innovative, competitive and environmentally-sustainable.

The NDT and Construction Management Research Group, is part of the Institute for Infrastructure and Environment at University of Edinburgh. The research themes are Non Destructive Testing and Construction, Project and Infrastructure Management. The Group undertakes research and investigation in the processes and products of the built environment.

3.9.3 Research Income

Scottish universities received a total of £6.4 million in research grants and contracts income in the construction industry in 2005/06. This amounts to 2% of the total research grants and contracts income received by Scottish universities in 2005/06. Of this, the Heriot-Watt University (£1.9 million), University of Dundee (£1.4 million), University of Edinburgh (£0.8 million) and the University of Strathclyde (£0.7 million) were the largest recipients, accounting for 74% of all research grants and contracts income received by Scottish universities in the industry

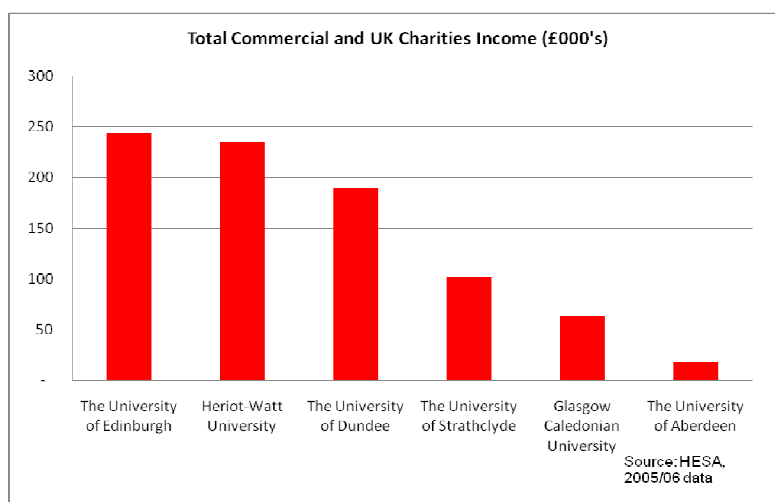
Figure 3.36: Total Research Grants and Contracts Income



Commercial Research Income in Construction

Of the £6.4 million received by Scottish universities in research grants and contracts income, £0.9 million (14%) was commercial and UK charities income. the University of Edinburgh (£0.24 million), Heriot-Watt University (£0.24 million), University of Dundee (£0.20 million) and the University of Strathclyde (£0.10 million) were the four biggest recipients accounting for 85% of the total commercial and UK charities income received by Scottish universities.

Figure 3.37: Total Commercial and UK Charities Income



3.9.4 Workforce

A total of 666 academic professionals were employed by Scottish universities in the construction industry. This makes it the second smallest, next to the tourism industry, of the 13 priority industries both in terms of academic professionals employed by Scottish universities as well as total research income received by Scottish universities.

Of the total number of academic professionals employed, 61% (408) are employed in either in a research only or a combined research and teaching capacity. At least 307 (75%) of the 408 are employed in both research and teaching capacities.

Students

The most construction related academic fields are civil engineering and architecture, and will be the ones under investigation here.

A total of 575 construction related higher degrees were awarded in Scotland in 2005/06, of which 20 were PhD degrees. 30% of them were delivered by Herriot-Watt University alone (175 degrees), while the remaining 400 were fairly evenly spread across ten other Scottish Universities, although Edinburgh University playing a slightly more important role with 65 degrees awarded in 2006.

Figure 3.38: Staff Numbers

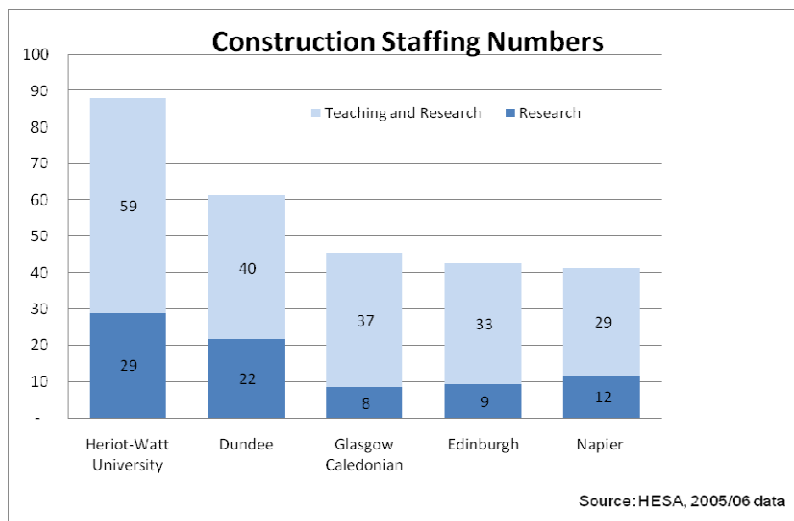


Figure 3.39: Number of Higher Degrees Awarded 2005/06

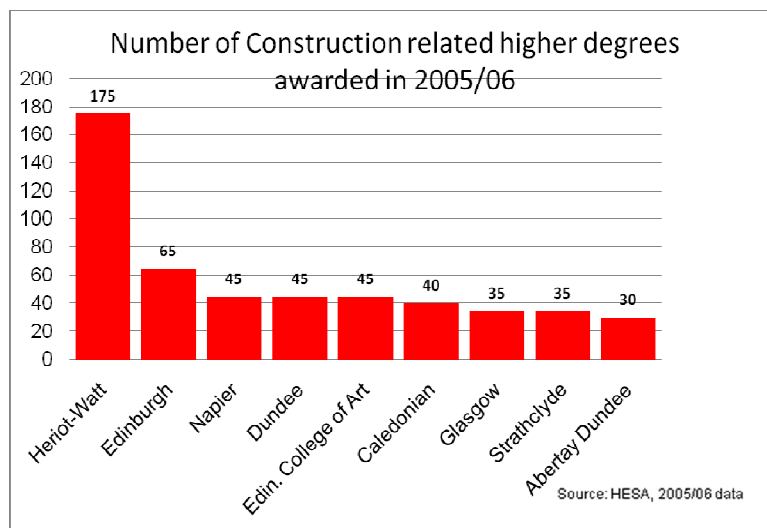




Table 3.9: High impact institutions

Institution	Income and Expenditure £ million		Staff FTE	Research Only Staff FTE	Teaching and Research FTE	Workforce		Delivery	Rank
	Research Income	Commercial/ Charities Research Income				Higher Degree Awards	PhD Awards	Most Common Publications and Citations	
Heriot-Watt	£1.9	£0.2	123	29	59	175	..	-	1
Dundee	£1.3	£0.2	99	22	40	45	..	-	2
Edinburgh	£0.8	£0.2	55	9	33	65	..	-	3
Strathclyde	£0.7	£0.1	62	5	31	35	..	-	4
Glasgow Cal.	£0.5	£0.06	82	8	37	40	..	-	5
Napier	£0.5	£0.02	62	12	29	45	..	-	6
ALL Scotland	£6.4	£0.9	666	96	311	575	20	-	

3.10 Textiles

3.10.1 Overview

In 2006 there were 450 textile companies in total in Scotland, directly employing around 17,000 people and with a turnover of £1,084 million. Almost half of all companies reported increasing levels of productivity, leading to increased profit margins. 40% of these export overseas, and the export sales account for around £390 million. USA is the biggest export market, followed France, Germany, Italy and Japan.

The objective of 2007-2010 strategy for the textile industry is to create:

“a flexible, innovative and dynamic industry characterised by leading design and R&D, and globally recognised brands.”

Innovation is one of the key strategic priorities and innovative products and services need to be exploited to develop competitiveness and market opportunities. This is achieved by developing collaborative cross-industry projects to exploit expertise, by encouraging linking design innovation to technical ability and leveraging technical academic work to increase productivity.

3.10.2 Key Academic Centres

There are two important strands of the textile industry – technical textiles and fashion textiles. Glasgow School of Art and Edinburgh College of Art are main university players in the Scottish fashion industry, while Heriot-Watt University, and its School of Textiles, has expertise in technical textiles and the commercialisation of these. Technical textiles include woven, non-woven, knit structure and design products and these are primarily aimed at medical, transportation and environmental markets.

Heriot-Watt is a key partner of TechniTex Faraday Partnership.⁴⁰ The partnership is backed by the DTI and the Engineering and Physical Sciences Research Council (EPSRC), and brings together, in addition to Heriot-Watt, the two leading UK universities in textile technology – Leeds and UMIST – with the British Textile Technology Group (BTTG), the largest independent textile research trade organisation in the UK.

The TechniTex Faraday Partnership for Technical Textiles is one of four Faraday Partnerships which aim to help companies work with the UK's leading researchers and produce innovative new products and processes to re-invigorate the UK textiles industry. The textiles industry has changed dramatically over the last 10-15 years, and a lot of the manufacturing has moved outside Scotland. This has also had an effect on the technological aspect of the industry.

⁴⁰ www.technitex.org

There is a lack of expert knowledge in Scotland, and the UK expertise is primarily in Nottingham, Manchester, Leeds and Bolton. There are however opportunities in Scotland, but limited understanding between industry and academia. Timescale and intellectual property rights are issues which limit collaboration and commercialisation. The industry team at SE is aware of this issue and has funded a project whereby an external consultant will work toward bridging this gap.

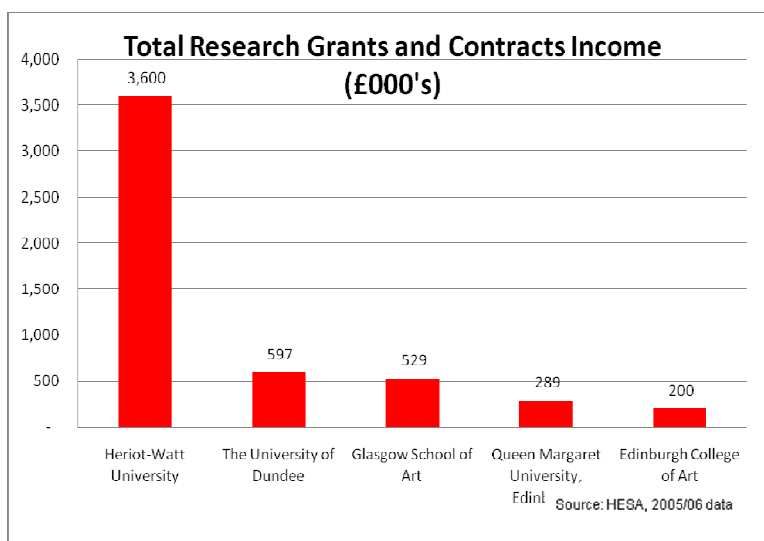
3.10.3 Research Income

Research grants and contract income totalling £5.6 million was generated by Scottish universities in 2005/06 in the textiles industry. This accounts to only 1% of the total research grants and contracts income generated by all Scottish universities. This ranks the industry second last (after the tourism industry) amongst the 13 priority industries in terms of research grants and contracts income.

The Heriot-Watt University dominates the research grants and contracts income, accounting for 65% (£3.2 million) of the total generated in the industry. The University of Dundee (£0.6 million) and the Glasgow School of Art (£0.5 million) are respectively the second and third biggest research grants and contracts income earners. The three universities account for 85% of the total research grants and contracts income generated by the industry.

Although a relatively small industry amongst Scottish universities, the textiles industry accounts for approximately 87% of the total research grants and contracts income generated by the Glasgow School of Art and 24% of the total research grants and contracts income generated by the Heriot-Watt University.

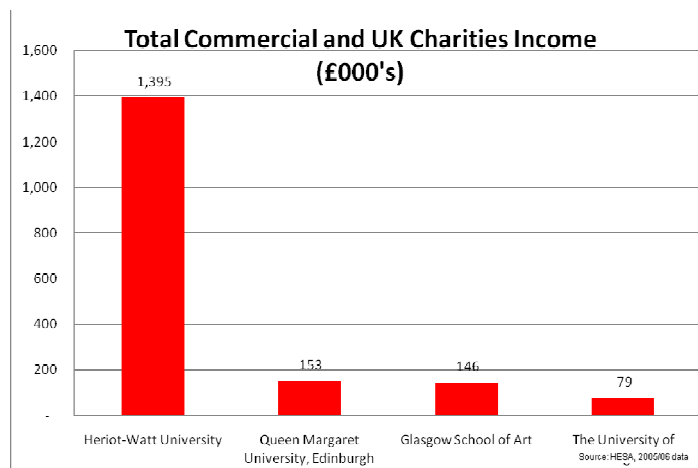
Figure 3.40: Total Research Grants and Contracts Income



Commercial Research Income in Textiles

Scottish universities, according to HESA 2005/06 data generated a total of £1.8 million from commercial and UK charities income. The University of Heriot-Watt dominated this accounting for 75% (£1.4 million).

Figure 3.41: Total Commercial and UK Charities Income

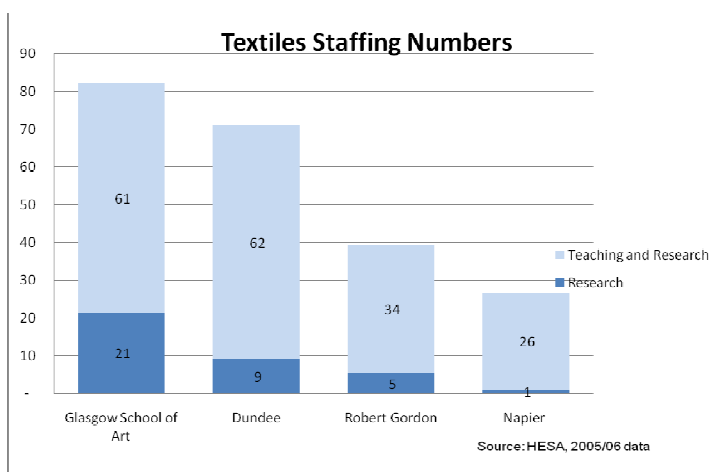


3.10.4 Workforce

Staff

A total of 710 academic professionals were employed by Scottish universities in the textiles industry in 2005/06, accounting for 2.3% of the total academic professionals employed by Scottish universities. Of this total nearly half (46%) are employed in either research only or research and teaching work with the universities. The three universities; Glasgow School of Art (82), University of Dundee (71) and the Robert Gordon University (39) employ 60% of all academic professionals employed in Scottish universities in the industry and involved textile research.

Figure 3.42: Staff Numbers



3.11 Tourism

3.11.1 Overview

The tourism industry is central to Scotland's economy. It contributes £4.2 billion to the economy each year and supports about 210,000 jobs which is around 9 per cent of all employment in Scotland.

An objective, identified in the 'Tourism Framework for Change', is to establish a culture of innovation in the tourism industry with tourism businesses. The nature of innovation relates primarily to:

- gathering and utilising **market intelligence**;
- investment in the development of **new and improved products and services**; and
- participation in **collaborative activity**.

3.11.2 Key Academic Centres

It is recognised that innovation in product and service development and in business processes is key to the competitiveness of the Scottish tourism industry. Market intelligence is important for innovation and enterprise. Tourism Intelligence Scotland has been developed as a joint initiative between Scottish Enterprise, Highlands and Islands Enterprise and VisitScotland, to support the tourism sector with market intelligence that can underpin growth and development.

However, while the importance of innovation is recognised in the industry, there are few links between universities and industries relating to tourism. The tourism industry is vocational in nature and the main academic activity is undergraduate courses in tourism with courses often having a hospitality focus with management training and entrepreneurship, for example Robert Gordon and Queen Margaret University are key players in this area.

Despite this concentration, ICT applications are being developed, mainly at Napier and Queen Margaret University, to assist the industry and two Proof of Concept applications in the software area have been assisted. This type of developments in ICT and software also need the support from Enabling Technologies and Engineering sector to enhance competitiveness in tourism.

Tourism innovation is limited in Higher Education institutions and the leading edge innovation originates primarily from industry. The relationship is often business-to-business and therefore collaborations and joint venture are primarily concentrated in the private sector.

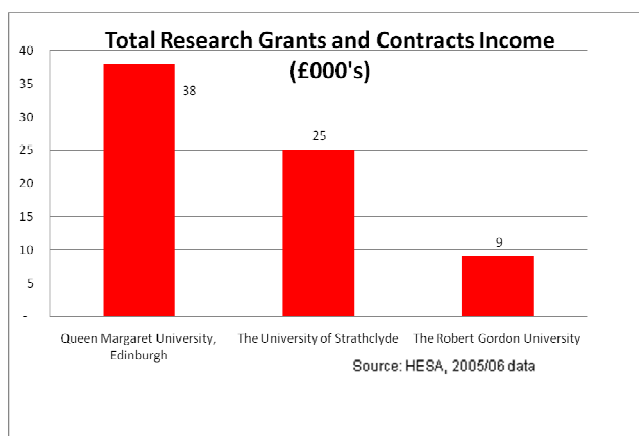
Tourism Knowledge Scotland (TKS)⁴¹ is a network consisting of all universities who are involved in tourism research. The network was set up to support the industry with research, consultancy and knowledge, and to facilitate the transfer of university research expertise into the industry. The purpose of TKS was to develop a co-ordinated approach towards research in terms of access, sharing of expertise and co-ordinating education expertise. However, the initiative has not been particularly successful or well received due to lack of commitment.

⁴¹ www.tks.org.uk

3.11.3 Total Research Income

HESA data suggests that the tourism industry is not a focus area of Scottish universities' research. Scottish universities generate only £74,000 in total research grants and contract income generated exclusively by the universities of Queen Margaret (£38,000), Strathclyde (£25,000) and Robert Gordon (£9,000). The insignificance of the industry is reflected in that it accounts for less than 1% of research income for all universities except for the University of Queen Margaret for which it accounts a mere 1%.

Figure 3.43: Total Research Grants and Contracts Income



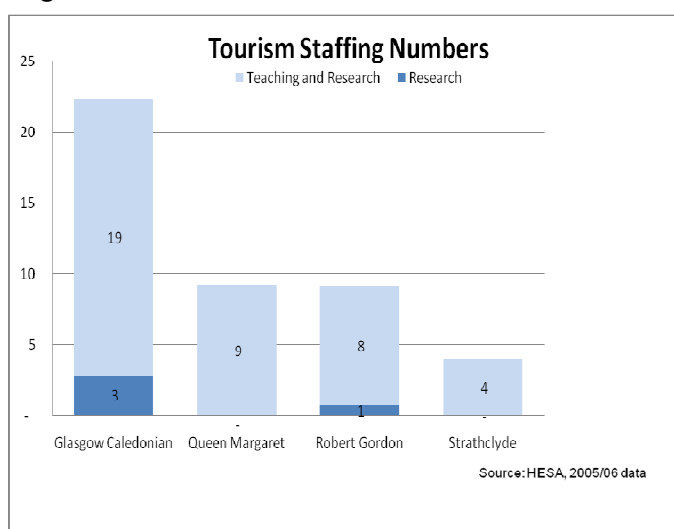
Scottish universities generate only £21,000 in commercial and UK charities income. This is generated by two universities; the University of Strathclyde (£16,000) and the Queen Margaret University (£5,000).

3.11.4 Workforce

Staffing

The industry has 91 academic professionals employed in Scottish universities with slightly over half (45) employed for either research only or research and teaching in the industry. Only the universities of Queen Margaret (9), Strathclyde (4) and Robert Gordon (9) and Glasgow Caledonian (22) registered employing academic professionals engaged in research in the industry.

Figure 3.44: Staff Numbers

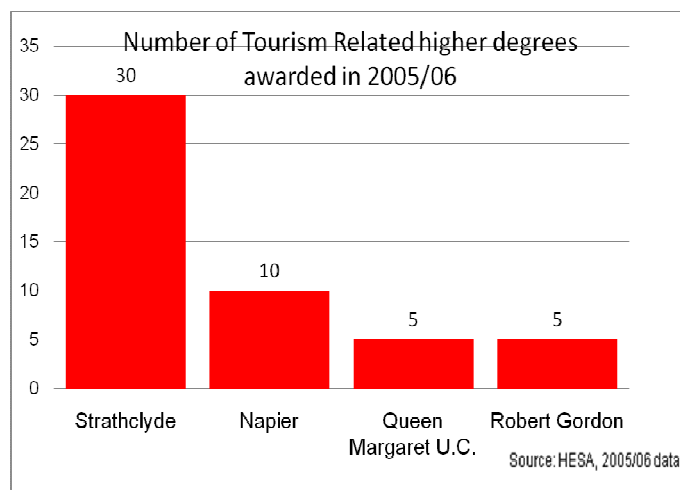


Students

The data available made it impossible to isolate PhD degrees from other Higher degrees (such as Masters). Therefore, we will here refer to the whole “Higher degrees” category, bearing in mind that PhD degrees probably make up less than half of this broad category.

In the 2005/06 academic year in Scotland, 50 Higher degrees have been awarded in fields relating to tourism. The University of Strathclyde alone accounts for 60% of the total, with 30 degrees awarded.

Figure 3.45: Number of Higher Degrees Awarded 2005/06



4. University Research Overview

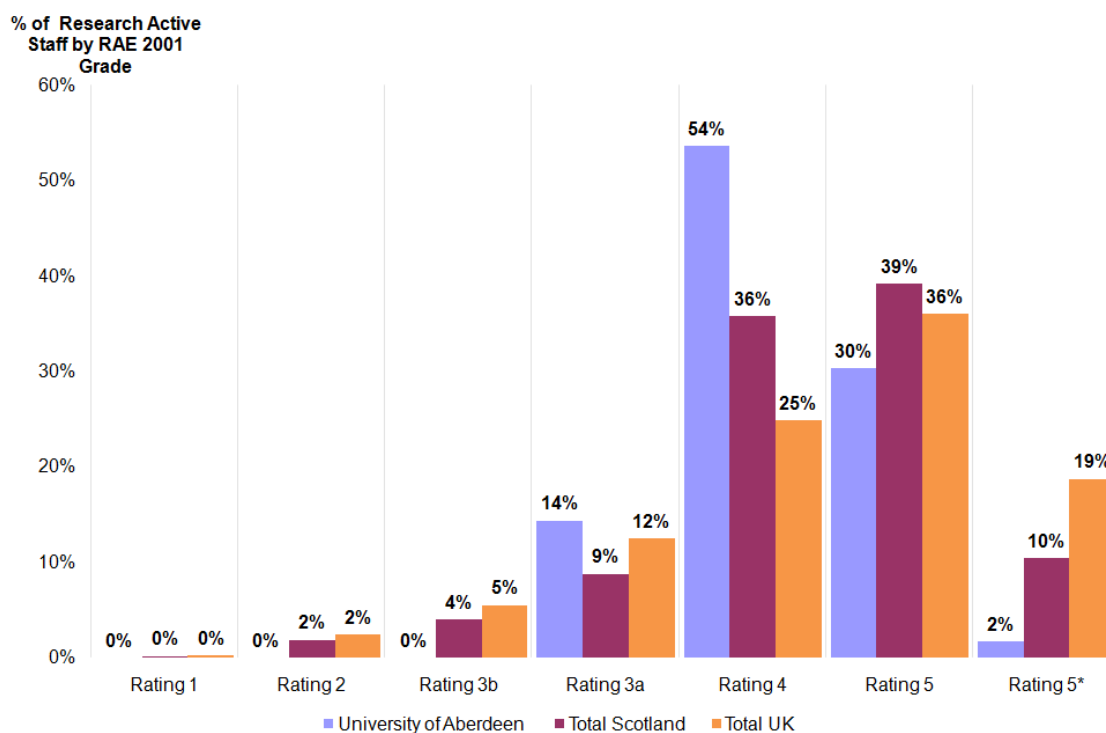
4.1 Aberdeen City and Shire

4.1.1 University of Aberdeen

4.1.1.1 Research Quality

In the 2001 Research Assessment Exercise (RAE), the university gained just one 5* rated department, but this (French) was not relevant for a Priority Industry.

Figure 4.1: Performance in the 2001 Research Assessment Exercise



In addition, Aberdeen received 9 ratings at grade 5, of which 6 were related to Priority Industries (Community-based Clinical Subjects, Agriculture (Plant & Soil Science), Physiology, Biological Sciences, Pure Mathematics and Town and Country Planning). This relatively modest performance is demonstrated in the chart above, showing that just 32% of research active staff were working in 5 or 5* rated departments, compared with 49% for Scotland as a whole.

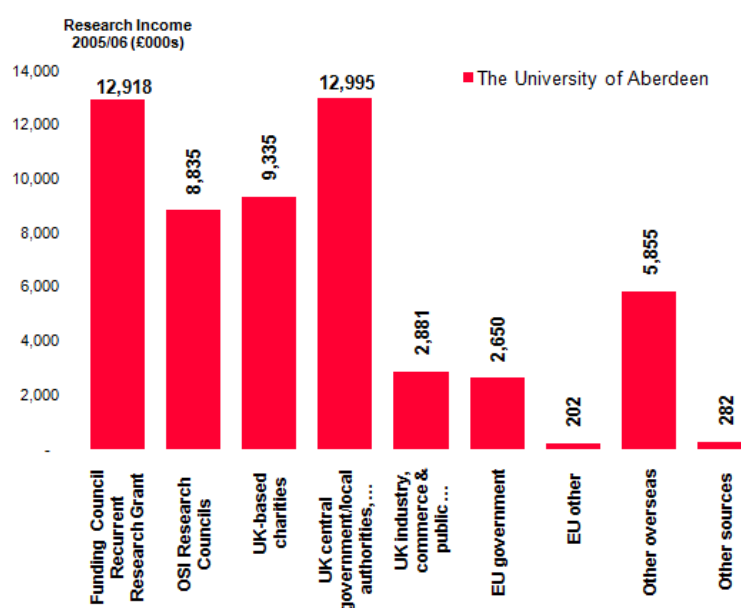
The university had a further 19 awards at grade 4, of which 9 relate to priority industries, including subjects such as Statistics and Operational research, Computer Science, General Engineering, Clinical Laboratory Sciences, Hospital-based Clinical Subjects, Psychology, Earth Sciences, Applied Mathematics, and Accounting and Finance. The University will have hopes of substantially improving upon the RAE2001, when the RAE 2008 results are announced this December.

Total Research Income

The University of Aberdeen is, in a Scottish context, the fourth largest university in terms of total research income, with £56.0 million in 2005/06, of which £43.0 million is in the form of research grants and contracts income.

Given the University's relative lack of success in the RAE 2001, the University draws in a relatively small proportion (15.8%) of its income from OSR Research Councils, such as the Medical Research Council, but does gain 16.7% from UK based charities, including those funding research into cancer and neural conditions.

Figure 4.2: Total Research Income Attained in 2005/06

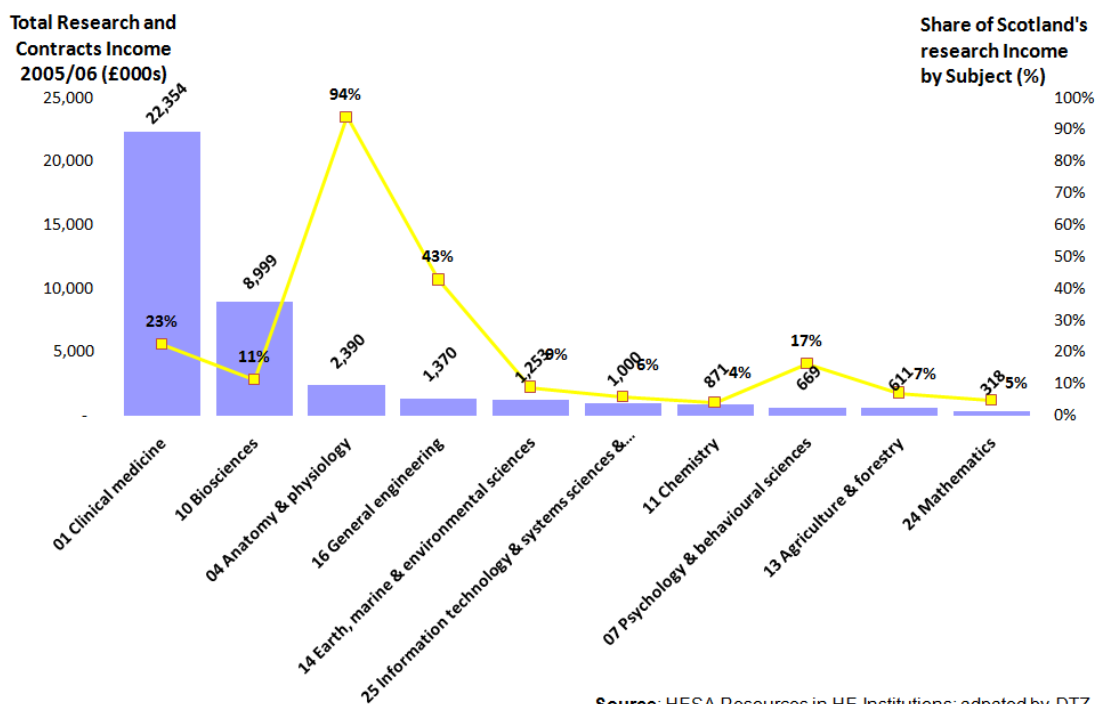


Source: HESA (2005/06)

In total, the University raised just £18 million from these two sources, but a further £13.0 million was raised from sources including NHS Hospital Trusts, and this may be explained by the strong collaborative relationship between NHS Grampian and the University, which has its Medical School located at the site of the Aberdeen Royal Infirmary. The University raised just £2.9 million from UK commercial sources, although we are aware that good linkages are emerging with Wyeth Pharmaceuticals in particular, in areas such as the study of osteoporosis and issues surrounding human fertility.

In terms of key subjects that are of relevance to the Priority Industries, Clinical medicine draws in almost £22.4 million in funding for research contracts, some 23% of the total for Scotland in that subject. Biosciences is the next most significant in scale (£9.0 million, or 11% of all research in Scotland in the subject), while research in areas such as Anatomy and Physiology (£2.4 million) accounts for 94% of all research in Anatomy and Physiology in Scotland. General Engineering (£1.4 million) is next in significance to the University.

Figure 4.3: University of Aberdeen: Top Priority Industry-related Research, by Subject, 2005/06: Total Research Contracts Income and Share of Total in Scotland for Subject



Source: HESA Resources in HE Institutions; adapted by DTZ

Priority Industries

Life Sciences: Aberdeen generated a total of £34.4 million in research grants and contracts income for Life Sciences disciplines. The University attracts a smaller proportion (30%) of its income from commerce and charities, but has a greater reliance upon health trust funding, with 24% coming of its £34.4 million coming from this source, and 15% from overseas.

As is demonstrated by the dominance of clinical medicine, biosciences and anatomy and physiology at the University, Aberdeen is an integral player in the Scottish Universities Life Sciences Alliance (SULSA) and the Translational Medicine Research Collaboration (TMRC)⁴². The University of Aberdeen's close relationship with NHS Grampian, with which it has an excellent collaborative record, is, in part, responsible for the University engaging in work with Wyeth and in support to the TMRC project.

Researchers at the University of Aberdeen are conducting a study of young women under the age of 40 attempting to understand why these women develop breast cancer. The studies focus on the possibility that the natural body systems that protect the cell's own genetic material against damage aren't functioning properly. Researchers are investigating how nutrients interact with genes in cells and how these effects might be important in a normal cell changing into a cancer cell. Patients in Aberdeen were one of the first cohorts involved in testing of new anti-cancer drugs for treatment of patients with breast cancer.

⁴² See Life Sciences section for other members

Patients have also participated in Aberdeen trials to understand the role of new imaging techniques such as Positron Emission Topography (PET) and magnetic resonance imaging. These techniques are being examined to understand how they can be used both to diagnose patients with cancer and also how they can be helpful in understanding how patients are responding to treatment.

Aberdeen has been engaged in clinical trials to test whether patients prescribed a statin at the same time as receiving an injection of the osteoporosis drug, bisphosphonate, will have a reduction in the adverse effect profile of the drug. The university has been collaborating with Wyeth through Women's Health and Musculoskeletal Biology (WHMSB) in Discovery Research at Wyeth. WHMSB is devoted to the development of the next generation of safe and effective therapies, as well as providing disease-modifying therapies for musculoskeletal conditions for both men and women.

Under the direction of Dr. Leonard Freedman, a team of scientists at Aberdeen is carrying out cutting edge research in: Contraception (both female and male), Endocrine Disorders (including menopausal therapies), Osteoporosis, Osteoarthritis, and Orthobiologics.

Aberdeen has a high proportion of staff in dedicated research functions and produces around 90 PhDs per annum, the third highest figure in Scotland. The University has a significant role to play in the study of Endocrinology & metabolism and also plays a significant role in oncology-related research.

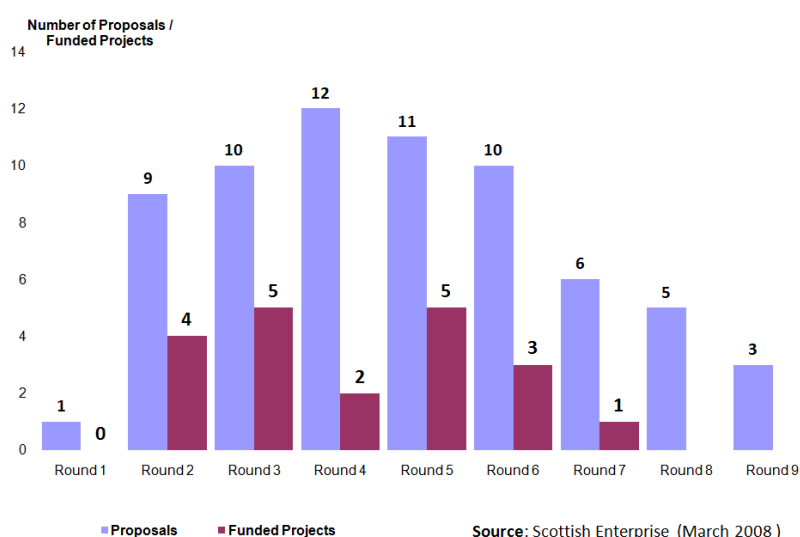
The University of Aberdeen-Rowett Institute merger will offer significant opportunities for synergies and 'bigger science'.

Commercialisation

University of Aberdeen has been particularly active in pursuit of Scottish Enterprise funding, under Proof of Concept, with 20 out of 59 proposals receiving funding, i.e. a 33.9% success rate, although in rounds 6 and 7, the success rate has dropped to 25% (4 successes from 16 proposals).

Aberdeen has had some significant success in generating patents, with 137 being recorded⁴³ between 2002 and 2006; more than University of Edinburgh over the same period, although from the data it is not possible to establish their relative value.

Figure 4.4: PoC Proposals / Funded Projects

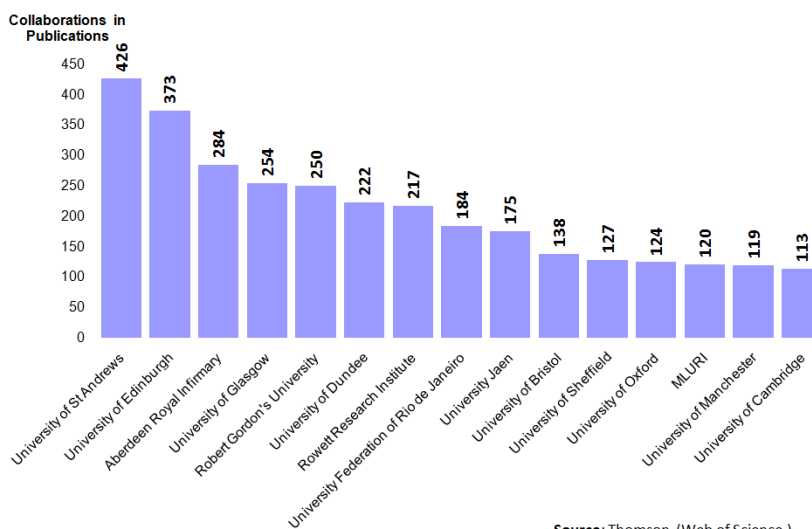


⁴³ UK Higher Education Research Yearbook 2007, Evidence Ltd

Figure 4.5: Number of Collaborations in Publications

Citations & Publications

University of Aberdeen received 259 citations in the World's seven foremost scientific⁴⁴ journals over the period 2000 to 2007, or 8.7% of the total of 2,990 for all Scottish research establishments. The university has produced an average of 1,408 published items per annum over the period 2000-2007 and had 11,422 abstracted papers over that period.



Source: Thomson (Web of Science)

The top 7 key collaborators with whom Aberdeen work are all based in Scotland, i.e. St Andrews, Edinburgh, Aberdeen Royal Infirmary, University of Glasgow, RGU, Dundee and the Rowett Research Institute, with which the University is to merge. Other collaborations from the rest of the UK or overseas include: Rio de Janeiro, University Jaen, Bristol, Sheffield and Oxford.

⁴⁴ Proceedings of the Royal Society, Science, Nature, Proceedings of the National Academy of Sciences of the United States of America, British Medical Journal, The Lancet, and New England Medical Journal.

Table 4.1: High Impact institutions – University of Aberdeen

Institution	Income and Expenditure £ million			Workforce			Delivery	Rank*
	Research Income (£million)	Commercial/ Charities Research Income (£ million)	Staff FTE	Research Only Staff FTE	Teaching and Research FTE	PhD Awards (Higher Degrees)	Most Common Publications and Citations	(
Life Sciences	£34.4	£10.2	1,034	423	249	90 (195)	Biochemistry and molecular biology, Microbiology Pharmacology and pharmacy Endocrinology and metabolism Neurosciences	4
Energy	£3.5	£0.9	170	49	60	34 (155)	-	6
All Subjects	£43.0	£12.2	2,816	534	684	165 (880)	-	3

Note: Due to industry definitions rows are not mutually exclusive. For example Physics contributes significantly in Energy, Digital Markets and Enabling technologies and Aerospace, Defence and Marine. Each row demonstrates the current potential resources relevant to each industry.

* Rank among other universities based on total research grants and contracts income in each priority industry

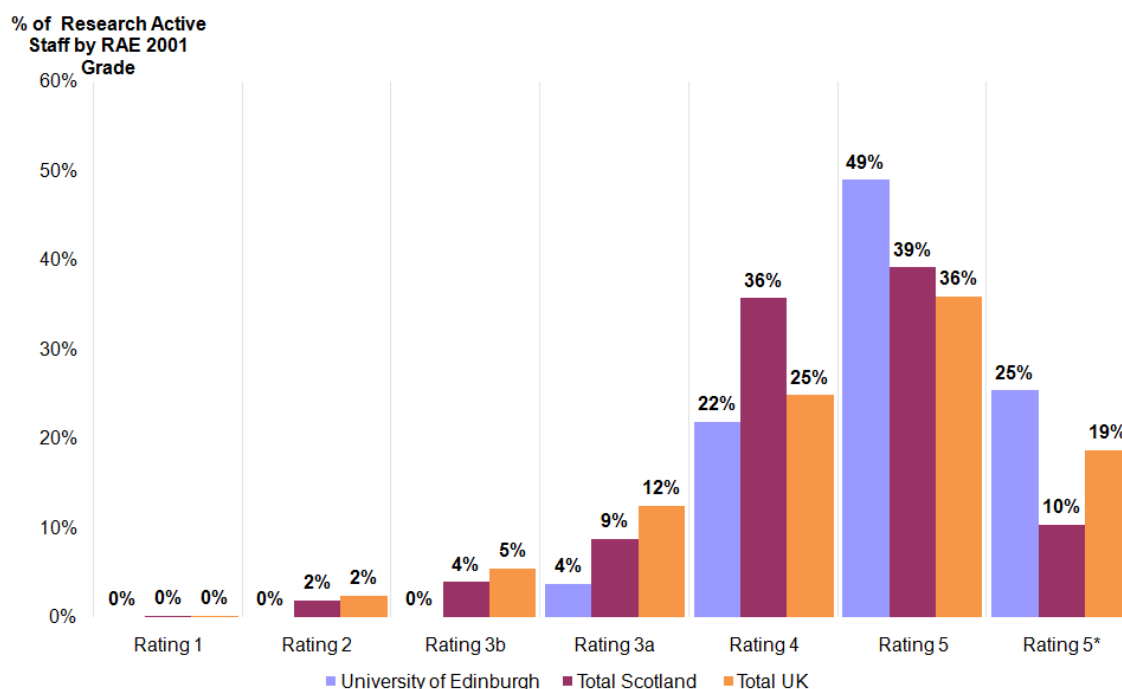
4.2 East

4.2.1 University of Edinburgh

4.2.1.1 Research Quality

The University of Edinburgh is renowned worldwide for having delivered many major breakthroughs in medical research through the ages. In the 2001 Research Assessment Exercise (RAE), the university gained a total of nine 5* rated departments, of which four (Hospital-based Clinical Subjects, Computer Science, Electrical and Electronic Engineering and Pure Mathematics) are of relevance to Priority Industries.

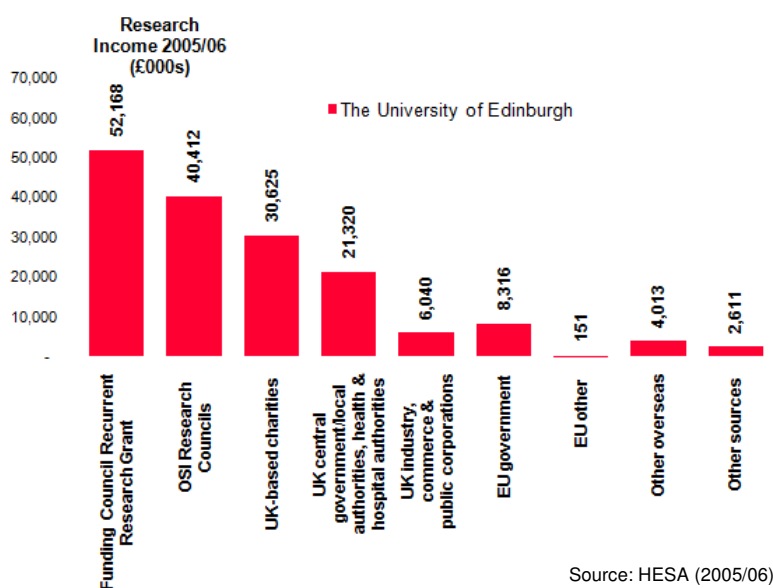
Figure 4.6: Performance in the 2001 Research Assessment Exercise



Edinburgh received 19 ratings at grade 5, of which 8 were related to Priority Industries (Biological Sciences, Veterinary Science, Physics, Earth Sciences, Chemistry, Civil Engineering, Applied Mathematics and Accounting and Finance).

This very strong performance is demonstrated in the chart above, showing that 74% of research active staff were working in 5 or 5* rated departments. The university had a further 16 awards at grade 4, of which 9 relate to priority industries, including subjects such as Pharmacology, Chemical Engineering and Mechanical, Aeronautical and Manufacturing Engineering.

Figure 4.7: Total Research Income Attained in 2005/06



Total Research Income

The University of Edinburgh is, in a Scottish context, the clear leader in terms of total research income, with £165.7 million in 2005/06, and anecdotal evidence of further growth since that date.

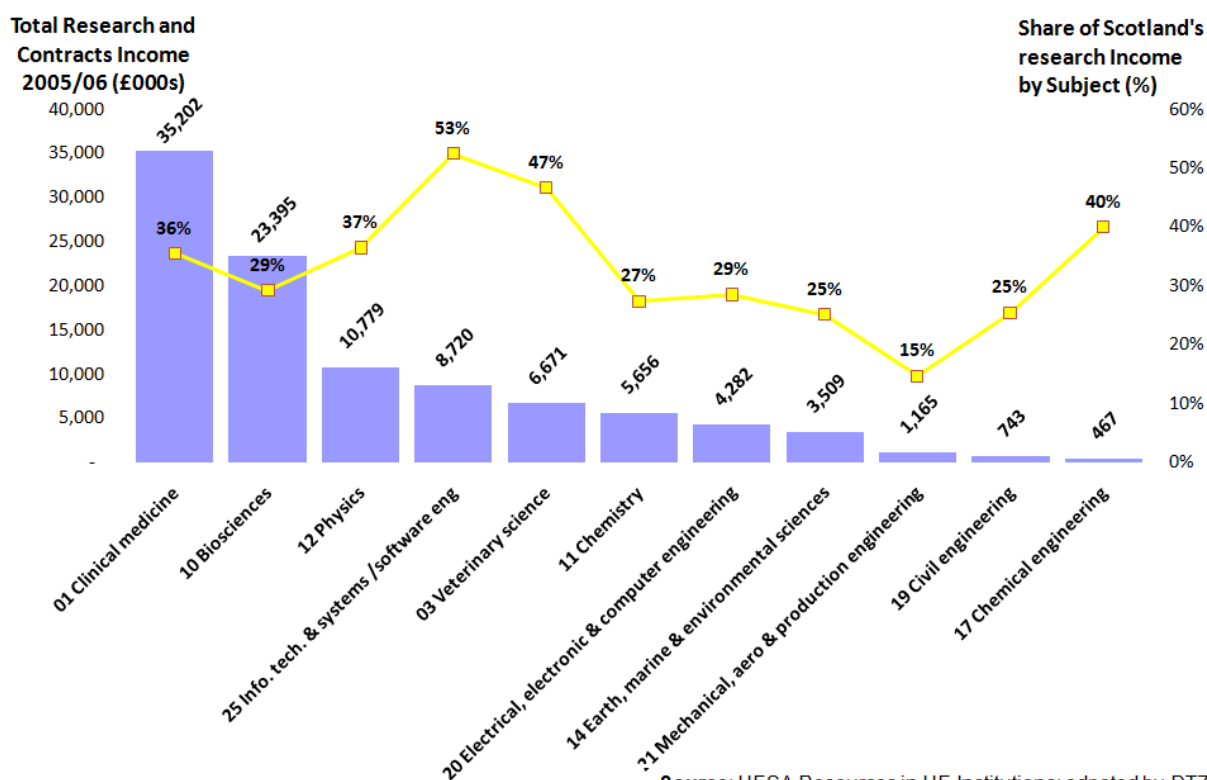
Unsurprisingly, perhaps, given the University's strength in subjects of significance to Life Sciences and its success in the RAE 2001, the University draws in a significant proportion (24.4%) of its income from

OSR Research Councils, such as the Medical Research Council, and 18.5% from UK based charities, including those funding research into cancer and neural conditions.

In total, the University raised £71 million from these two sources alone, and a further £21 million from sources including NHS Hospital Trusts. The University raised just £6.0 million from UK commercial sources, although this was the largest amount raised by any university in Scotland.

In terms of key subjects that are of relevance to the Priority Industries, Clinical medicine draws in £35 million in funding for research contracts, some 36% of the total for Scotland in that subject. Biosciences is the next most significant in scale (£23.4 million), while research in areas such as Physics (£10.8 million) and Informatics (£8.7 million) are also key to the University. The latter accounts for 53% of all research income for that subject in Scotland. Veterinary Science (47%) and Chemical Engineering (40%) are also at the forefront of research in Scotland.

Figure 4.8: University of Edinburgh: Top Priority Industry-related Research, by Subject, 2005/06: Total Research Contracts Income and Share of Total in Scotland for Subject



Source: HESA Resources in HE Institutions; adapted by DTZ

Priority Industries

Life Sciences: The University of Edinburgh dominates life sciences research grants and contracts income with just over £66.5 million in (2005-06) or 32% of the total for Scotland. Life Sciences accounts for 59% of all research grants and contracts income for the University.

- The Scottish Centre for Regenerative Medicine (CRM) is based at Little France, Edinburgh. The CRM brings together into a single unit, clinicians from the University of Edinburgh Medical School with existing research groups, who have a proven track record in clinical stem cell research and therapy, from the Institute for Stem Cell Research. CRM claims to be one of the largest critical masses of basic and clinical researchers in its field in Europe. From 2010, CRM will be co-located in a new state-of-the-art building on the site shared by the Edinburgh Royal Infirmary and the University's clinical research facilities.
- Easter Bush Research Consortium (EBRC) is another key project and will be almost unique in the global Life Sciences sector. It will establish the largest centre of its type in Europe and will be in the top 3 in the World in Animal Health, linking large animal health issues, human health and biochemicals. Partners include Roslin Institute, the Royal (Dick) Veterinary College, Edinburgh, Moredun Institute, SAC and the Neuropathogenesis Unit (NPU) of the University of Edinburgh.

- Edinburgh is a key player in both the Scottish Universities Life Sciences Alliance (SULSA) and the Translational Medicine Research Collaboration (TMRC)⁴⁵

The formal merger with the Roslin Institute will further cement Edinburgh's dominance of research relating to the sector in Scotland.

Digital Markets and Enabling Technologies: Edinburgh University School of Informatics⁴⁶, headed by Professor Michael Fourman, is a 5* A rated department. The university state that the school is the largest of its kind in the UK. The school attracts research grant income of more than £5 million per annum in areas such as Computer Science, Cognitive Science, Computational Linguistics and Artificial Intelligence and works with Sun Microsystems and BT.

Other key initiatives include the:

- The Scottish Microelectronics Centre (SMC)⁴⁷ for incubation, and research and development in the semiconductor sector.
- The FPGA (Field Programmable Gate Arrays) High Performance Computing Alliance (FHPCA)⁴⁸, which aims to revolutionise the development of "mission-critical applications" and help deal with the massive processing requirements needed in areas such as drug design, defence, seismology, medical imaging and mobile telecoms.
- The Edinburgh-Stanford Link⁴⁹ is a £6 million research, training and commercialisation initiative, specialising in speech and language technology. The initiative is a collaborative venture between the University of Edinburgh, Stanford University and Scottish Enterprise.

Interaction between this area and **Financial Services** could be developed through development of predictive software programmes for the finance industries.

Energy: The University of Edinburgh also dominates energy sector research in terms of research grants and contracts income with just over £26.6 million in (2005-06) or 27% of the total for Scotland, with the School of Physics being pivotal. Energy-related activity accounts for 23.4% of all research grants and contracts income at Edinburgh. **Professor Robin Wallace** is Head of The Institute for Energy Systems at the University, and his research interests include network integration of distributed renewable energy generation and marine energy. He is Principal Investigator and Finance Lead of the EPSRC SuperGen Marine Energy Research Consortium and Co-Director of the UK Energy Research Centre. In total, Edinburgh is engaged in three SUPERGEN workstreams (follow links to see partner institutions working with Edinburgh):

⁴⁵ See Life Sciences section for other members

⁴⁶ <http://www.inf.ed.ac.uk/>

⁴⁷ <http://www.scotmicrocentre.co.uk>

⁴⁸ <http://www.fhpca.org>

⁴⁹ <http://www.edinburghstanfordlink.org>

- **SUPERGEN Excitonic Solar Cells**⁵⁰, made from organic compounds, dyes, gels or liquids rather than the conventional silicon, use 'excitons' or electronically excited molecules, stimulated by absorption of light, to transfer energy between molecules for a few tens of nanometres until they reach an interface between two materials where the energy is used to create an electron in one material (phase) and a hole in the other, creating an electrical current.
- The **SUPERGEN Marine Energy Research Consortium**⁵¹ is tackling a wide range of challenges associated with wave and tidal power and involves a large number of industry partners. The consortium is aiming to make marine energy more attractive to investors, reducing investment risk and uncertainty through greater knowledge.
- The **SUPERGEN Future Network Technologies Consortium**⁵² is researching ways to integrate small-scale renewable energy sources into the electrical energy system, and looking at how energy networks may need to develop in the future.

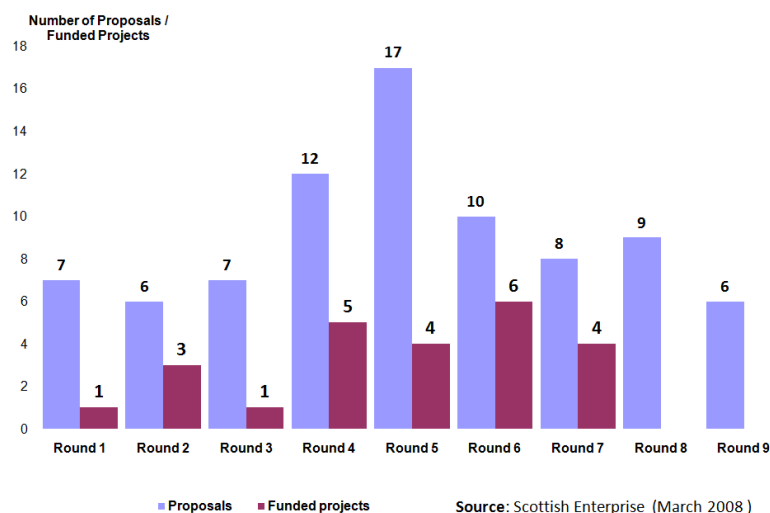
Chemical Sciences: Edinburgh is the leading Scottish University for Chemistry and is perceived to be highly organised and well resourced. The School of Chemistry⁵³ at Edinburgh was rated 5* in the most recent Research Assessment Exercise (RAE2001). Key areas for research within the School include: the Chemistry/Biology interface, experimental and theoretical chemical physics, molecular synthetic chemistry, and materials chemistry. Research interactions exist with other disciplines such as Physics, Biology, Materials Science and Engineering.

Commercialisation

University of Edinburgh has been particularly active in pursuit of Scottish Enterprise funding, under Proof of Concept, with 24 out of 67 proposals receiving funding, i.e. a 35.8% success rate, and in rounds 6 and 7, the success rate averaged 55% (10 successes from 18 proposals).

In terms of commercialisation, the University of Edinburgh has been highly successful and one spin-out, MTEM, has been cited as key case, with commercial development of existing seismic research and research on electromagnetism. Their success was not in terms of blue skies research, but rather a major

Figure 4.9: PoC Proposals / Funded Projects



⁵⁰ <http://www.epsrc.ac.uk/ResearchFunding/Programmes/Energy/Funding/SUPERGEN/ExcitonicSolarCells.htm>

⁵¹ <http://www.epsrc.ac.uk/ResearchFunding/Programmes/Energy/Funding/SUPERGEN/MarineEnergyResearch.htm>

⁵²

<http://www.epsrc.ac.uk/ResearchFunding/Programmes/Energy/Funding/SUPERGEN/FutureNetworkTechnologies.htm>

⁵³ <http://www.chem.ed.ac.uk/research/index.html>

development or breakthrough in existing technologies or research. Wolfson Microelectronics is another highly successful spin-out, with projected turnover of circa \$50 million in 2008/09.

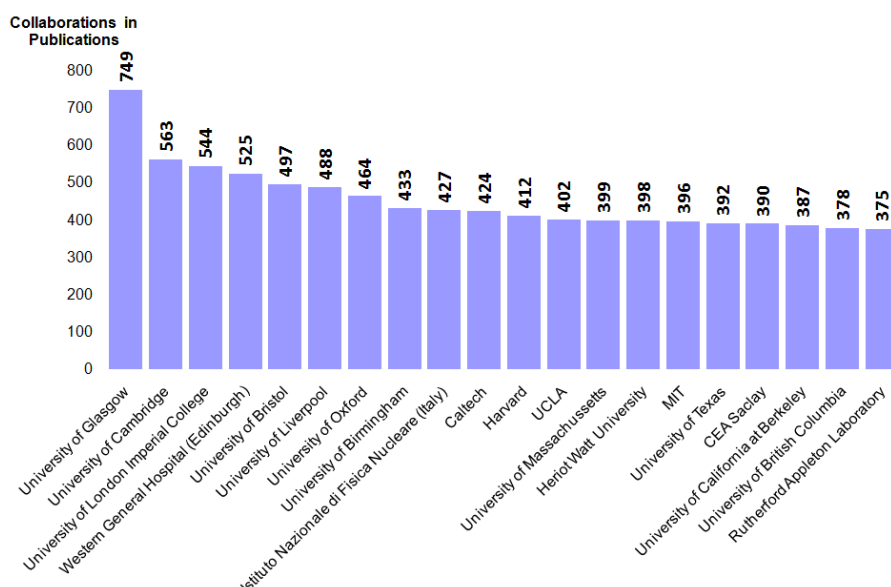
The University has established ERI – Edinburgh Research Innovation – as a stand-alone business unit with its own director. This is a key intermediary vehicle in pursuit of commercialisation opportunities. In addition, the Edinburgh Pre-Incubation Service (EPIS) attracts entrepreneurs to work in their specialist areas to generate business activity from the University.

Edinburgh has considerable success in generating patents, with 133 being recorded⁵⁴ between 2002 and 2006.

Citations & Publications

University of Edinburgh received 832 citations in the world's seven foremost scientific⁵⁵ journals over the period 2000 to 2007, or 27.8% of the total of 2,990 for all Scottish research establishments. The university produced an average of 2,935 published items per annum over the period 2000-2007 as well as 23,870 abstracted papers over that period.

Figure 4.10: Number of Collaborations in Publications



Many significant collaborations are with British or international academic partners such as Cambridge, Imperial College, Oxford, INFN in Italy, Harvard, UCLA, Massachusetts, MIT, University of Texas, and University of California at Berkeley. It is of note that, despite the £6 million investment by Scottish Enterprise in establishing the Edinburgh-Stanford Link⁵⁶, Stanford University does not yet feature in the top 20 collaborative partnerships. Although this in part can be explained by the fact that the link is focused on language technology, but is also being used to foster entrepreneurship training, and technology transfer and commercialisation which would not be reflected in citations or publications *per se*.

⁵⁴ UK Higher Education Research Yearbook 2007, Evidence Ltd

⁵⁵ Proceedings of the Royal Society, Science, Nature, Proceedings of the National Academy of Sciences of the United States of America, British Medical Journal, The Lancet, and New England Medical Journal.

⁵⁶ <http://www.edinburghstanfordlink.org/>

Table 4.2: High impact institutions – University of Edinburgh

Institution	Income and Expenditure £ million			Workforce			Delivery Most Common Publications and Citations	Rank*
	Research Income (£million)	Commercial/ Charities Research Income (£ million)	Staff FTE	Research Only Staff FTE	Teaching and Research FTE	PhD Awards (Higher Degrees)		
Life Sciences	£66.5	£31.1	1,978	655	412	210 (355)	Biochemistry & molecular biology; Genetics and heredity; Neurosciences; Cell biology; Ecology; Evolutionary biology	1
Energy	£26.6	£3.50	792	239	233	141 (320)	Applied physics / Materials science	1
Digital Markets	£25.0	£3.1	686	220	176	n/a (360)	-	1
Aerospace, Defence and Marine	£19.7	£2.4	561	164	175	n/a (115)	-	1
Chemical Sciences	£6.1	£0.9	156	66	42	n/a (40)	-	2
Financial Services	£1.1	£0.1	169	14	100	n/a (260)	-	5
Construction	£0.8	£0.2	55	9	33	n/a (65)	-	3
All Subjects	£113.5	£36.7	6,360	1,127	1,440	515 (2,025)		1

Note: Due to industry definitions rows are not mutually exclusive. For example Physics contributes significantly in Energy, Digital Markets and Enabling technologies and Aerospace, Defence and Marine. Each row demonstrates the current potential resources relevant to each industry.

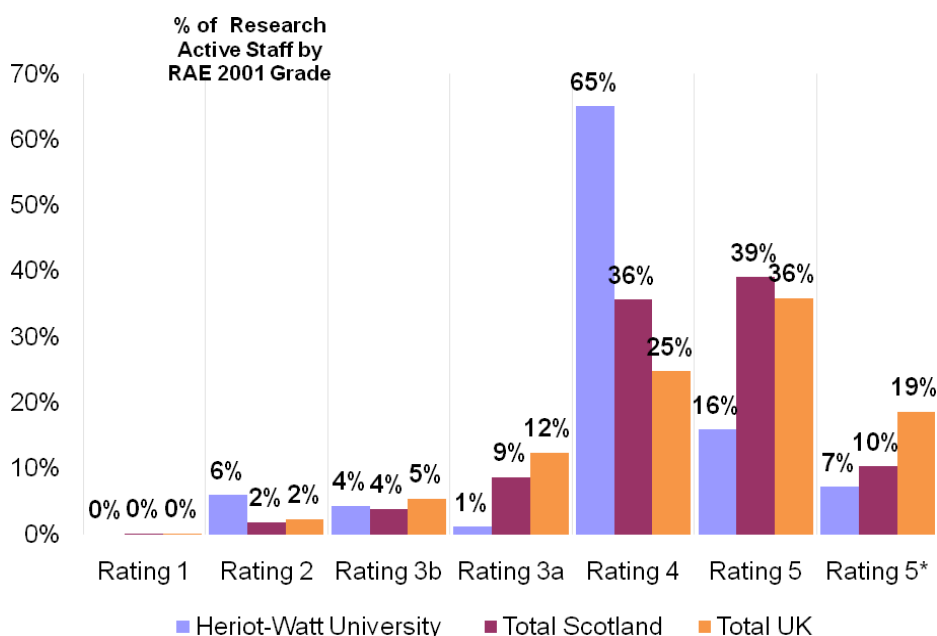
* Rank among other universities based on total research grants and contracts income in each priority industry

4.2.2 Heriot-Watt University

4.2.2.1 Research Quality

Heriot-Watt University gained a total of just one 5* rated department in the 2001 Research Assessment Exercise (RAE), i.e. Mineral and Mining Engineering. In addition, Heriot-Watt received three ratings at grade 5, of which all were related to Priority Industries (Applied Mathematics, Statistics and Operational Research and Built Environment).

Figure 4.11: Performance in the 2001 Research Assessment Exercise



This relatively low achievement in the 2001 RAE is demonstrated in the chart above, showing that just 23% of research active staff were working in either 5 or 5* rated departments, i.e. this is far below the Scottish average of 49% and UK figure of 55%. The University had a further 10 awards at grade 4, of which nine relate to priority industries (Food Science and Technology, Chemistry, Physics, Computer Science, Chemical Engineering, Civil Engineering, Electrical and Electronic Engineering, Mechanical, Aeronautical and Manufacturing Engineering, and Business and Management Studies).

Total Research Income

Heriot-Watt University is, in a Scottish context, seventh largest in terms of funding a significant force in terms of total research income, with £25.4 million of research income, from all sources, in 2005/06. Of this, £15.1 million was in research grants and contracts.

Unsurprisingly, perhaps, given the University's relative weakness in the RAE, OSR Research Councils income is comparatively modest in aggregate terms, but this still constitutes some 25.5% of total research income. Given the University's lack of engagement with Life Sciences, it is perhaps unsurprising that it draws just £0.4 million (1.4%) of its total research income from UK based charities, compared with 16% for Scotland as a whole.

By contrast, the University raised £3.6 million from UK commercial sources, which equates to 14.2% of all income, while for Scotland the comparable figure was just 5.8%. This reflects the commercial applicability of the research undertaken at Heriot-Watt in areas such as Energy.

In terms of key subjects that are of relevance to the Priority Industries, Mineral, metallurgy and materials engineering attracted £3.3 million in research grants and contracts income, i.e. 100% of the total in Scotland. Physics, particularly in relation to Energy, drew in £2.9 million, although this was just 10% of the total for Scotland in that subject.

Electrical, Electronic and Computer Engineering was the next most significant in scale (£1.7 million or 11% of the total for Scotland), while research in areas such as Architecture, Built Environment and Planning, at £1.4 million, constituted 41% of the total for Scotland.

Figure 4.12: Total Research Income Attained in 2005/06

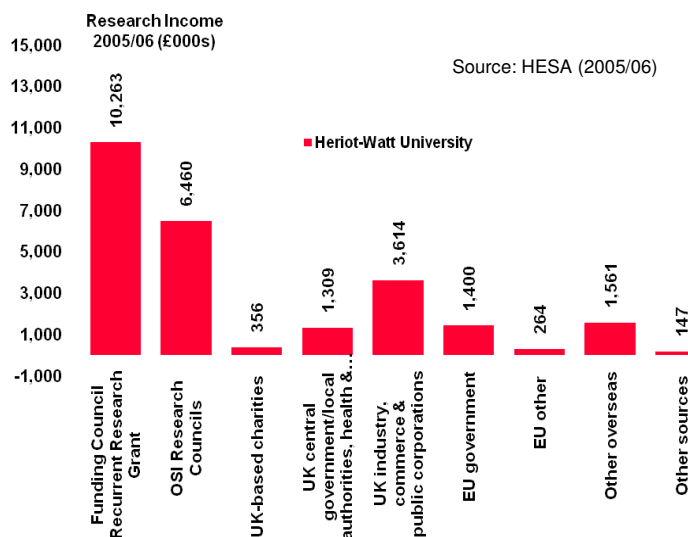
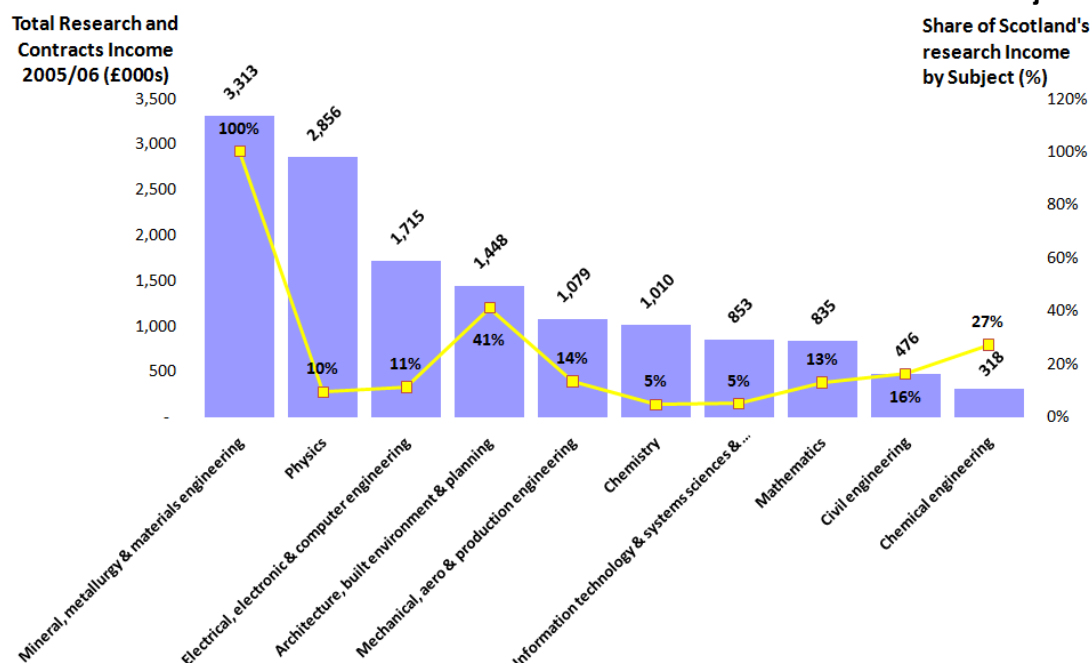


Figure 4.13: Heriot-Watt University: Top Priority Industry-related Research, by Subject, 2005/06: Total Research Contracts Income and Share of Total in Scotland for Subject



Source: HESA Resources in HE Institutions; adapted by DTZ

Priority Industries

Energy: Heriot-Watt University is part of the **SUPERGEN Marine Energy Research Consortium**⁵⁷ tackling a wide range of challenges associated with wave and tidal power and involving a large number of industry partners (see energy section).

Digital Markets and Enabling Technologies: Heriot-Watt University is the fourth highest recipient of research grants and contracts income in the digital markets and enabling technologies industry (£10.3 million) and the third highest recipient of total commercial and UK charities income (£2.9 million) – almost six times more than the University of Glasgow's total commercial and UK charities income. Total research grants and contracts income from the industry account for up to 66% of the university's total research grants and contracts income.

Aerospace, Defence and Marine: Heriot-Watt University is the fourth biggest total grants and contracts income recipient (£6 million) and the third highest total commercial research and UK charities income recipient.

⁵⁷ <http://www.epsrc.ac.uk/ResearchFunding/Programmes/Energy/Funding/SUPERGEN/MarineEnergyResearch.htm>

Chemical Sciences: The University is the fourth biggest total grants and contracts income recipient (£4.6 million) and the second highest total commercial research and UK charities income recipient (£1.5 million). The standard of chemical engineering research at Heriot-Watt was rated the highest (4A) among the Scottish chemical engineering departments in the latest (2001) Research Assessment Exercise.

Financial Services: Whilst not amongst the top five total research grants and contracts income recipients, The Heriot-Watt University is the second highest recipient of total commercial and UK charities income. Additionally it awarded the second highest number of financial services related higher degrees in 2005/06.

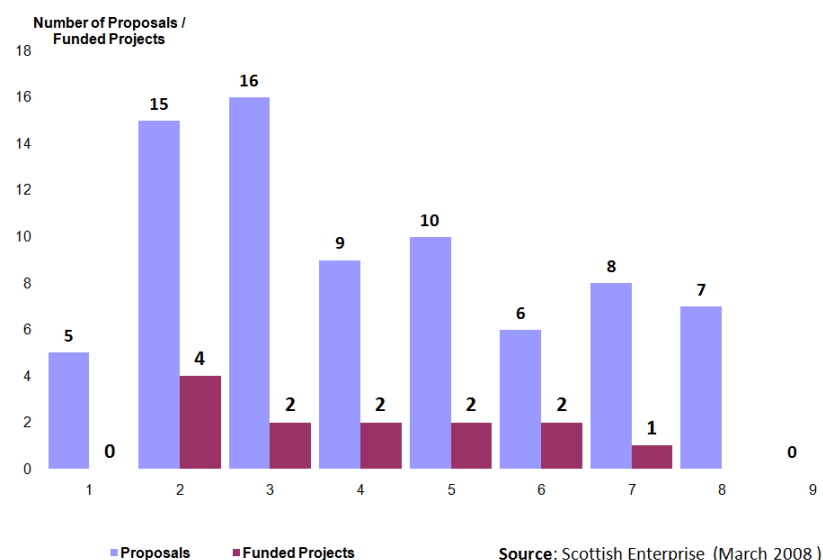
The university's Actuarial Mathematics and Statistics was the first department of its kind in the UK and is now one of the world's leading centres for teaching and research in these areas, achieving Grade 5 in the most recent UK Research Assessment to become the only centre for actuarial study to achieve such a high grade.

Construction: The university is the biggest recipient of total grants and contracts income (£1.9 million) and the second highest total commercial research and UK charities income recipient. The university's **School of the Built Environment** has been recognised with a high ranking in the last two UK government Research Assessment Exercises (RAE) and is the only one in Scotland to receive an RAE Grade 5 rating in both 1996 and 2001.

Commercialisation

Heriot-Watt has been characterised by declining engagement with Scottish Enterprise funding, under Proof of Concept, with just 13 out of 69 proposals receiving funding to the end of Round 7. The success rate is relatively poor, at just 18.8%, in comparison with Edinburgh, at almost 36% and Aberdeen at almost 34%.

Figure 4.14: PoC Proposals / Funded Projects

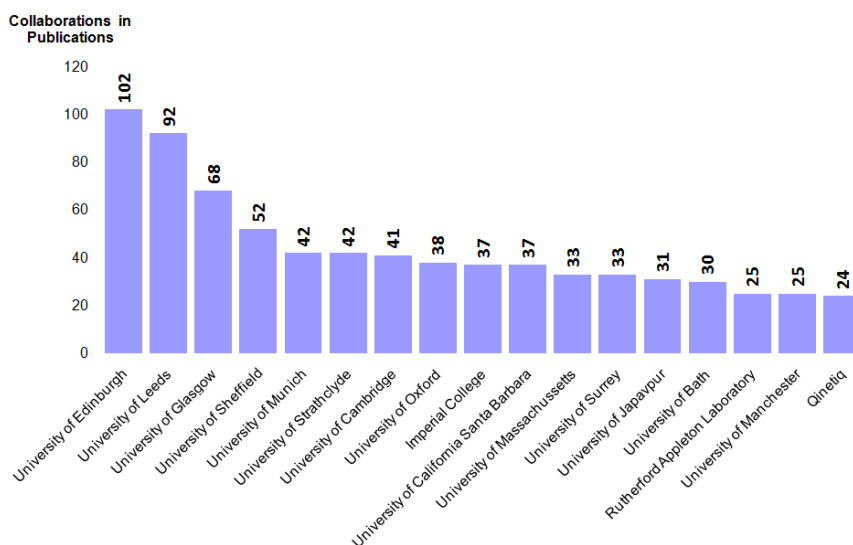


The University generated 22 spinout companies by 2006 using University intellectual property, and these firms employed approximately 202 FTE employees as at 2006. Heriot-Watt has had some modest success in generating patents, with 54 being recorded⁵⁸ between 2002 and 2006.

Citations & Publications

Heriot-Watt University received 29 citations in the World's seven foremost scientific⁵⁹ journals over the period 2000 to 2007, or just less than 1% of the total of 2,990 for all Scottish research establishments. The university has produced an average of 441 published items per annum over the period 2000-2007 and had 3,594 abstracted papers over that period.

Figure 4.15: Number of Collaborations in Publications



Source: Thomson (Web of Science)

The top two university collaborators with whom Heriot-Watt works are Edinburgh and Leeds, while Glasgow is a significant player. International collaborations exist with Munich, University of California at Santa Barbara, University of Massachusetts and University of Japavpur (also called Jadavpur). QinetiQ, a defence related research and development organisation, is also a key partner.

58 UK Higher Education Research Yearbook 2007, Evidence Ltd

59 Proceedings of the Royal Society, Science, Nature, Proceedings of the National Academy of Sciences of the United States of America, British Medical Journal, The Lancet, and New England Medical Journal.

Table 4.3: High impact institutions – Heriot-Watt University

Institution	Income and Expenditure £ million		Staff FTE	Research Only Staff FTE	Teaching and Research FTE	PhD Awards (Higher Degrees)	Delivery Most Common Publications and Citations	*Rank
	Research Income (£million)	Commercial/ Charities Research Income (£ million)						
Energy	£11.2	£3.1	354	121	110	58 (285)	-	5
Digital Markets & Enabling Technologies	£10.3	£2.9	386	125	118	n/a (210)	Engineering, electric and electronic Materials science, multidisciplinary Physics, applied	4
Aerospace, Defence and Marine	£5.9	£1.5	204	68	64	n/a (75)	-	4
Chemical Sciences	£4.6	£1.6	147	52	45	n/a (160)	Chemical engineering	4
Financial Services	£0.9	£0.3	183	12	97	n/a (340)	-	6
Construction	£1.9	£0.2	123	29	59	n/a (175)	-	1
All Subjects	£15.1	£4.0	1,507	191	369	100 (980)	-	7

Note: Due to industry definitions rows are not mutually exclusive. For example Physics contributes significantly in Energy, Digital Markets and Enabling technologies and Aerospace, Defence and Marine. Each row demonstrates the current potential resources relevant to each industry.

* Rank among other universities based on total research grants and contracts income in each priority industry

4.2.3 University of St. Andrews

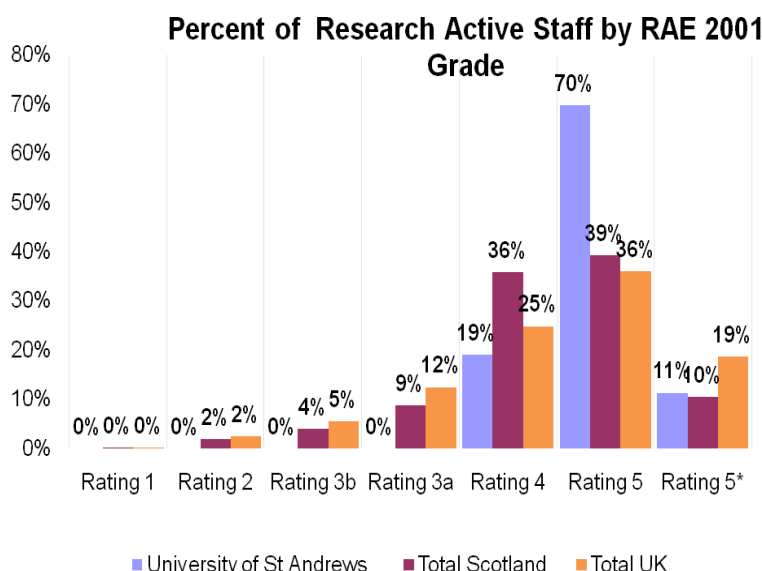
The University of St Andrews, as one of the

oldest universities in the world is a well known brand.

In the 2001 Research Assessment Exercise (RAE), the university gained a total of two 5* rated departments, of which one (Psychology) is of relevance to Priority Industries.

In addition, St Andrews received fifteen ratings at grade 5, of which seven were related to Priority Industries (Biological Sciences, Chemistry, Physics, Pure Mathematics, Applied Mathematics, Statistics and Operational Research and Computer Science). This relative concentration of score in the top two grades is demonstrated in the chart above, showing that 81% of research active staff were working in 5 or 5* rated departments, i.e. this is higher than for Edinburgh (74%), for example, and well above the national average (49%). The University had a further six awards at grade 4, of which two relate to priority industries (Economics and Econometrics, and Business and Management Studies).

Figure 4.16: Performance in the 2001 Research Assessment Exercise

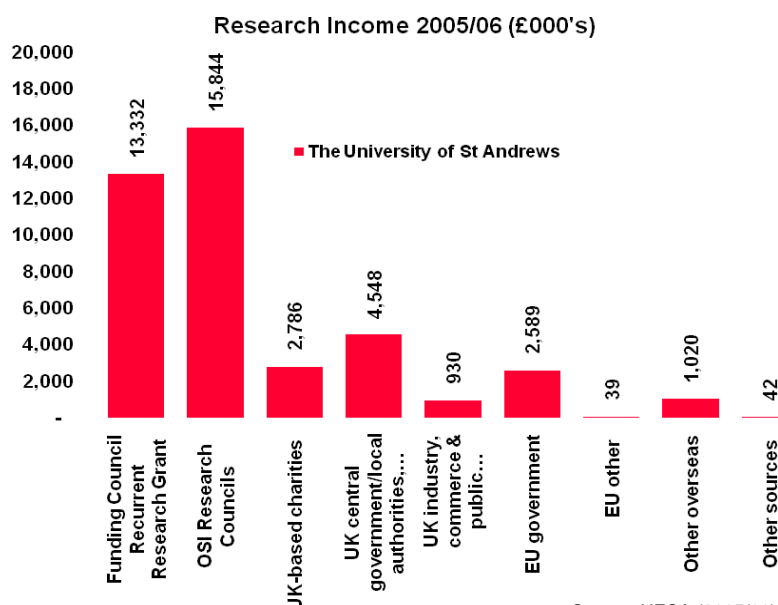


Total Research Income

The University of St Andrews is, in a Scottish context, a significant force in terms of total research income, with £41.1 million in 2005/06.

Unsurprisingly, perhaps, given the University's strength in subjects of significance to Life Sciences, Energy and Chemical Sciences and its relative success in the RAE 2001, the University draws in a very high proportion (38.5%) of its income from OSR Research Councils; this is the highest figure in Scotland. St Andrews draws just 6.8% of its total research income from UK based charities.

Figure 4.17: Total Research Income Attained in 2005/06

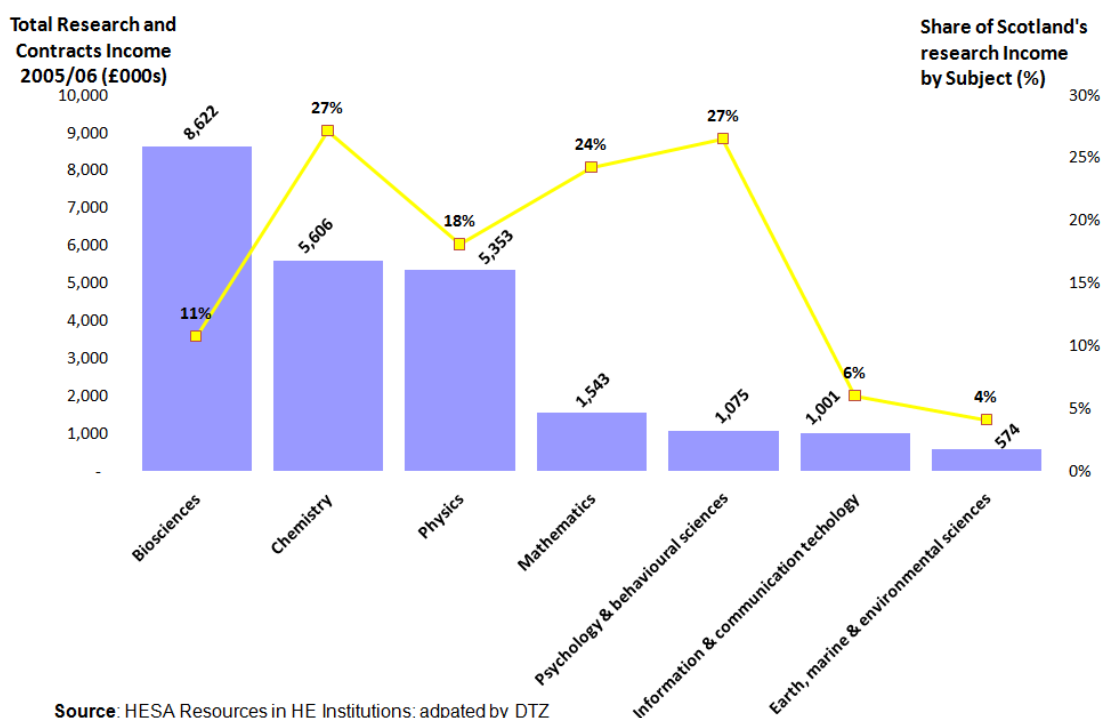


Source: HESA (2005/06)

The University raised just £0.9 million from UK commercial sources, despite collaboration with investors such as SASOL on energy projects.

In terms of key subjects that are of relevance to the Priority Industries, Biosciences draws in £8.6 million in funding for research contracts, some 10.8% of the total for Scotland in that subject. Chemistry was the next most significant in scale (£5.6 million or 27% of the total for Scotland), while research in areas such as Physics (£5.4 million or 18% of the total for Scotland) is also key to the University in underpinning its work in relation to the energy sector.

Figure 4.18: University of St Andrews: Top Priority Industry-related Research, by Subject, 2005/06: Total Research Contracts Income and Share of Total in Scotland for Subject



Priority Industries

Life Sciences: St. Andrews University was frequently cited amongst the universities hosting the core of life sciences research. The University is the fifth biggest recipient of total grants and contracts income (£10 million and twice that of the University of Strathclyde) and the sixth highest total commercial research and UK charities income recipient (£1.9 million)

Energy: St Andrews is part of the **Energy Technology partnership (ETP)** coordinating inter-institutional energy related research collaboration amongst Scottish universities. (see the Energy priority industry section of this report for further detail). Other features are:

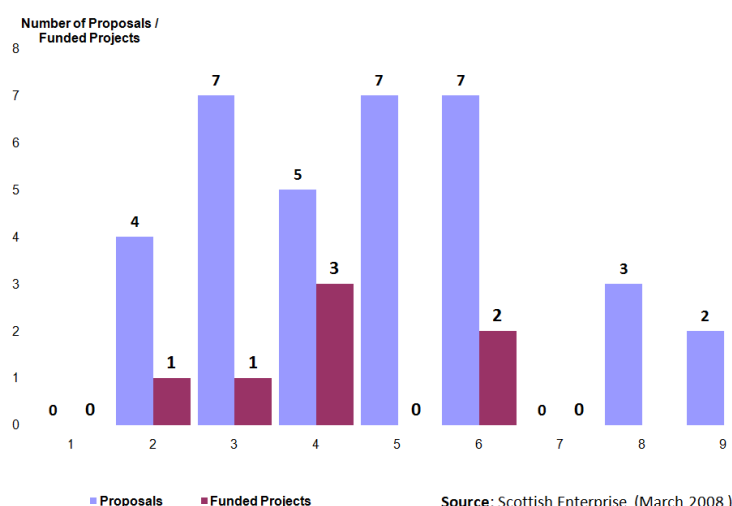
- The University is the fourth biggest recipient of total grants and contracts income (£11.5 million) and the fifth highest total commercial research and UK charities income recipient (£1.0 million)
- The university is part of the **SUPERGEN Energy Storage Consortium**⁶⁰ together with the University of Bath, University of Surrey, AEA Technology, Huntsman, Johnson Matthey, Mast Carbons, Rolls Royce and Valence Technology and the **SUPERGEN Fuel Cells**⁶¹.

Chemical Sciences: The university is one of the well regarded institutions in developing specialist research in chemical sciences and has a 5-rated Chemistry department (RAE 2001).

Commercialisation

The University of St Andrews has been less prolific than nearby Dundee in pursuit of Scottish Enterprise funding, under Proof of Concept, with seven out of 30 proposals receiving funding to the end of Round 7. However the success rate is relatively good in comparison with Dundee, at almost 29%. There is some evidence that St Andrews is less engaged in the later rounds of PoC, with a notable decline in the number of project proposals submitted.

Figure 4.19: PoC Proposals / Funded Projects



The University has generated 18 spinout companies between 1996 and 2006 using University intellectual property.

St Andrews has had some success in generating patents, with 69 being recorded⁶² between 2002 and 2006, with a total of 154 patents filed since 1996, and 117 invention disclosures⁶³ over that same period.

60 <http://www.epsrc.ac.uk/ResearchFunding/Programmes/Energy/Funding/SUPERGEN/EnergyStorage.htm>

61 <http://www.epsrc.ac.uk/ResearchFunding/Programmes/Energy/Funding/SUPERGEN/FuelCells.htm>

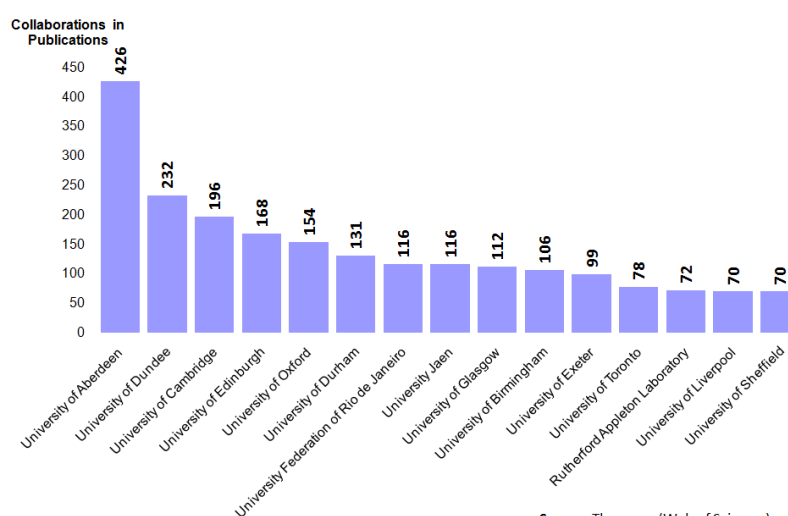
62 UK Higher Education Research Yearbook 2007, Evidence Ltd

63 <http://www.st-andrews.ac.uk/research/KnowledgeTransfer/>

St Andrews has established, in 1998, its **Research and Enterprise Services (RES)**⁶⁴ team at the New Technology Centre, which acts as an on campus location for businesses seeking to engage with the university. RES offers guidance and assistance in establishing collaborative or contract research between the university and commercial, government, EU and other overseas partners, as well as facilitation of licensing of intellectual property and the creation of spin-out companies.

Citations & Publications **Figure 4.20: Number of Collaborations in Publications**

University of St Andrews received 177 citations in the World's seven foremost scientific⁶⁵ journals over the period 2000 to 2007, or 5.9% of the total of 2,990 for all Scottish research establishments. The university has produced an average of 990 published items per annum over the period 2000-2007 and had 8,046 abstracted papers over that period.



Source: Thomson (Web of Science)

The top two collaborators with whom St Andrews works are based in Scotland, i.e. Aberdeen and Dundee, while Edinburgh is the fourth most significant partner. Other collaborations from the rest of the UK or overseas include: Cambridge, Oxford, Durham, Rio de Janeiro, University Jaen, Bristol, Manchester, Nottingham, SCRI, University College London, Cambridge and Oxford.

⁶⁴ <http://www.st-andrews.ac.uk/research-enterprise/>

⁶⁵ Proceedings of the Royal Society, Science, Nature, Proceedings of the National Academy of Sciences of the United States of America, British Medical Journal, The Lancet, and New England Medical Journal.

Table 4.4: High impact institutions – St. Andrews

Institution	Income and Expenditure £ million		Staff FTE	Research Only Staff FTE	Teaching and Research FTE	PhD Awards (Higher Degrees)	Delivery Most Common Publications and Citations	*Rank
	Research Income (£million)	Commercial/ Charities Research Income (£ million)						
Life Sciences	£10.0	£1.9	309	108	81	40 (65)	Astronomy & astrophysics Crystallography Biochemistry & molecular biology physical	5
Energy	£11.5	£1.0	289	130	63	51 (45)	..	4
Digital Markets & Enabling Technologies	£6.4	£0.5	159	68	44	n/a (15)	..	5
Aerospace, Defence and Marine	£5.9	£0.4	169	67	36	n/a (10)	..	5
Chemical Sciences	£5.6	£0.6	121	63	27	n/a (20)	Chemistry	3
Financial Services	£1.8	£0.2	135	31	73	n/a (145)	..	3
All Subjects	£27.8	£3.7	1,870	316	438	150 (480)		6

Note: Due to industry definitions rows are not mutually exclusive. For example Physics contributes significantly in Energy, Digital Markets and Enabling technologies and Aerospace, Defence and Marine. Each row demonstrates the current potential resources relevant to each industry.

* Rank among other universities based on total research grants and contracts income in each priority industry

4.3 South

The South of Scotland region does not host any universities apart from a small number of satellite campuses. Satellite campus developments are typically focused on teaching activities rather than research. However, while we have not been able to isolate income data for these centres, we are aware of the following:

The University of Glasgow has established the Crichton Carbon Centre at Dumfries, which works in partnership with a number of organisations to develop a research portfolio at Dumfries. It is currently exploring the issue of embodied energy in traditional and modern buildings.

The centre is also conducting research as part of the carbon opportunities programme and evaluating the possibility for a regional carbon offsetting scheme. It is exploring novel approaches to carbon management in the supply chain and investigating the potential future development of biofuels in the region. Dr Rachel Dunk is Head of Research at the Centre.

www.carboncentre.org/component/option,com_frontpage/Itemid,1/

The Netherdale Campus of Heriot-Watt University is developed from the Scottish College of Textiles. The University has its Biomedical Textile Research Centre and Research Institute for Flexible Materials and Faraday TechniTex Partnership which collectively employ 3 research directors, 4 research associates, and two administrative staff.

It is likely that these activities will be of some significance to the development of the textiles sector. Research covers the major areas of textile technology, chemistry, clothing and textile design and frequently related management and computing disciplines. The University cites rapid development of the clothing industry from being skill-based to being technology-based as a lead to increased research effort in clothing.

www.tex.hw.ac.uk/SOTResearch.html

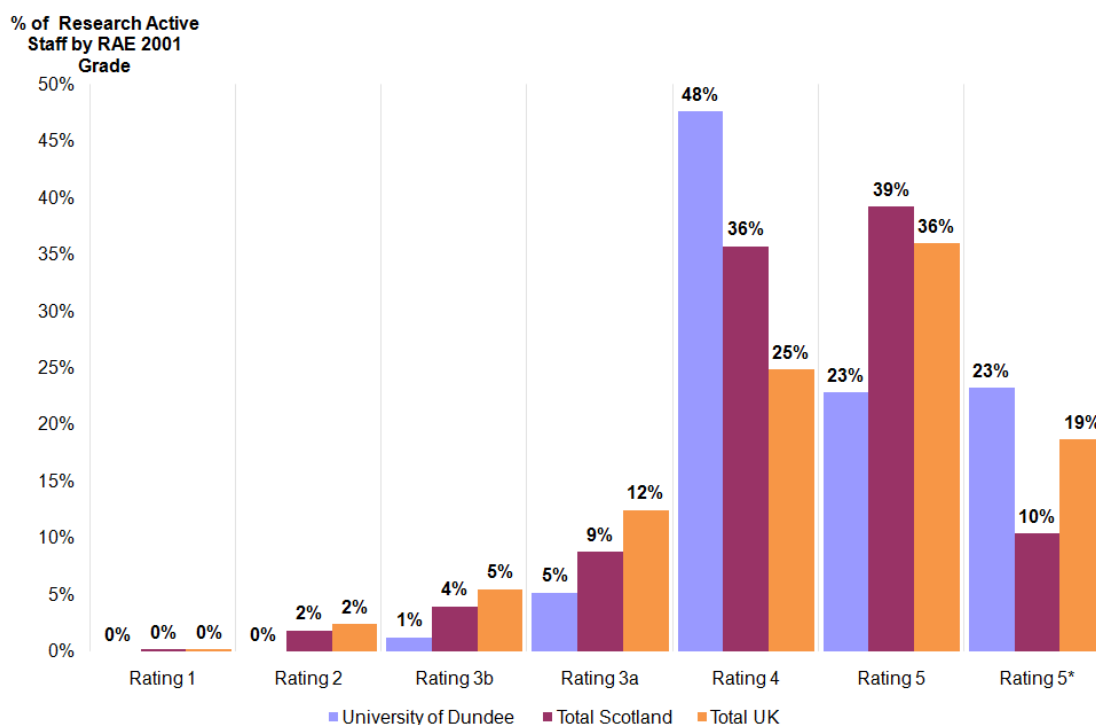
4.4 Tayside

4.4.1 University of Dundee

4.4.1.1 Research Quality

In the 2001 Research Assessment Exercise (RAE), the university gained just two 5* rated department, but both are highly relevant to Life Sciences (Clinical Laboratory Sciences and Biological Sciences).

Figure 4.21: Performance in the 2001 Research Assessment Exercise



In addition, Dundee received 6 ratings at grade 5, of which four were related to Priority Industries (Hospital-based Clinical Subjects, Clinical Dentistry, Applied Mathematics, and Civil Engineering). Dundee's moderate performance in terms of the RAE is reflected in the chart above, showing that some 46% of research active staff were working in 5 or 5* rated departments, compared with 49% for Scotland as a whole.

The university had a further ten awards at grade 4, of which six relate to priority industries, including subjects such as Community-based Clinical Subjects, Psychology, Computer Science, General Engineering, Accounting and Finance and Art and Design. The University will have hopes of substantially improving upon the RAE2001, when the RAE 2008 results are announced this December, as it has received considerably increased financial support in recent years.

Total Research Income

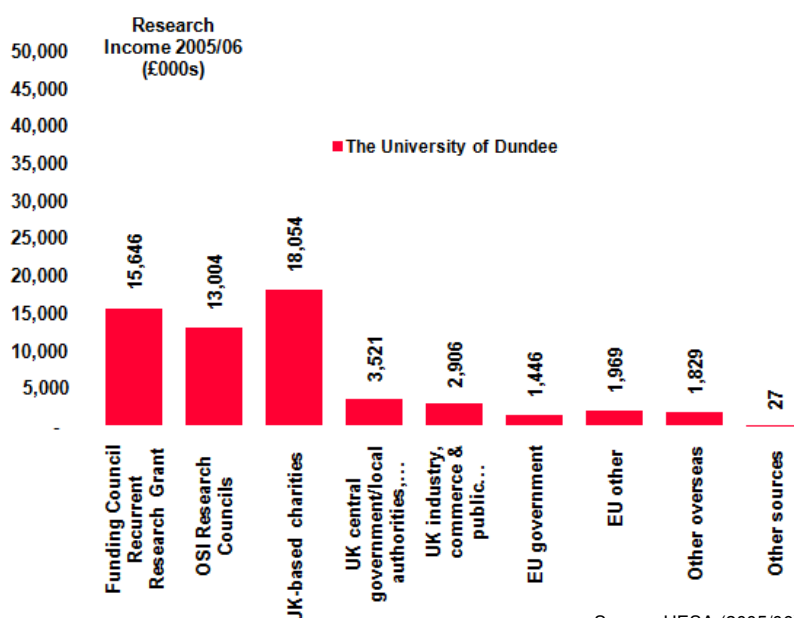
The University of Dundee is, in a Scottish context, the third largest university in terms of total research income, with £58.4 million in 2005/06, of which £42.8 million is in the form of research grants and contracts income.

Given the University's relatively modest profile in terms of the RAE 2001, the University does well in attaining a similar proportion (22.6%) of its income from OSR Research Councils, as is achieved by Edinburgh (24.4%) and Glasgow (23.1%). This is possibly due to the concentration of areas of excellence in Life Sciences disciplines. The University does particularly well with UK based charities, especially medical research charities, from which it received £18.0 million or 30.9% of its income, i.e. this is the main source of research income for Dundee, which in itself is highly significant.

Compared with Aberdeen, Dundee received relatively little (£3.5 million) from sources such as UK government or NHS Hospital Trusts. The University raised £2.9 million from UK commercial sources.

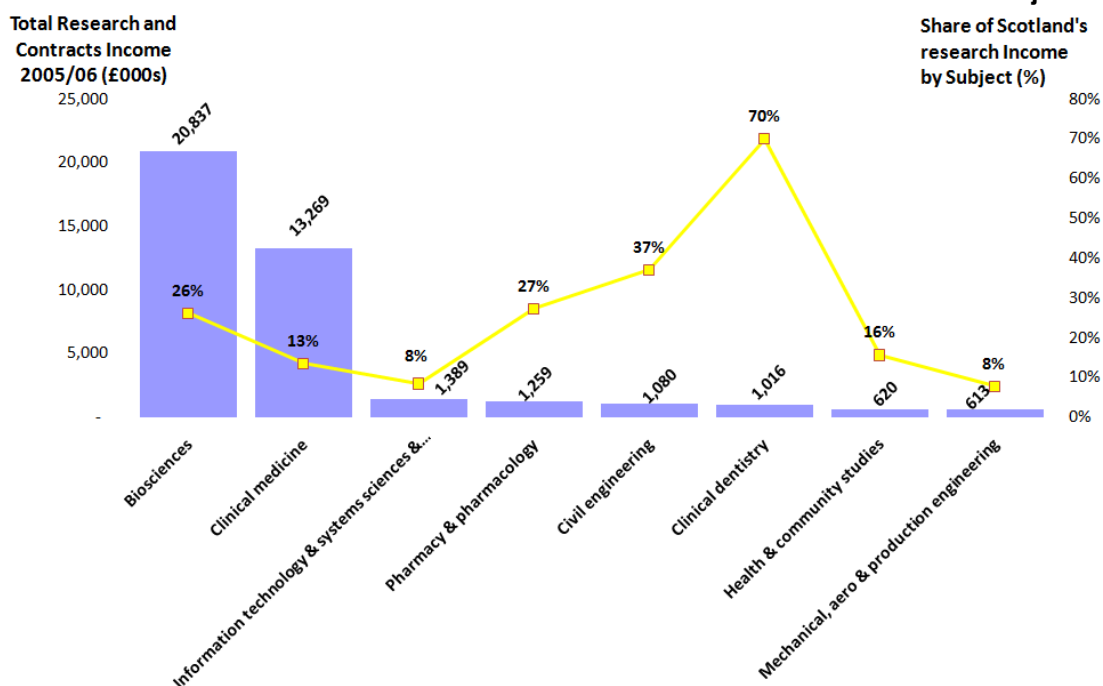
In terms of key subjects that are of relevance to the Priority Industries, Biosciences drew in almost £20.9 million in funding for research contracts, some 26.1% of the total for Scotland in that subject. Clinical Medicine is the next most significant subject discipline in scale (£13.3 million, or 13.4% of all research in Scotland in the subject), while research in areas such as Clinical Dentistry (£1.0 million) accounts for 70% of all research in the subject within Scotland. Pharmacy and Pharmacology (£1.3 million) accounts for 27% of all research in that discipline.

Figure 4.22: Total Research Income Attained in 2005/06



Source: HESA (2005/06)

Figure 4.23: University of Dundee: Top Priority Industry-related Research, by Subject, 2005/06: Total Research Contracts Income and Share of Total in Scotland for Subject



Source: HESA Resources in HE Institutions; adapted by DTZ

Priority Industries

Life Sciences: The University of Dundee is amongst the Scottish universities frequently cited as hosting the core of life sciences research. Some features of its work in Life Sciences are as follows:

- The university is at the forefront of work in the area of diabetes research and has substantial research strength in oncology.
- It is the third biggest earner of life sciences total research grants and contracts income with just over £37.2 million in (2005-06) or 18% of the total for Scotland. Over half of this income (£20.4 million) is commercial and UK charities income.
- Total life sciences research grants and contract income accounts for 87% of all research grants and income received by the University of Dundee making it, in relative terms, the most life sciences focused university in Scotland.
- The College of Life Sciences at the University of Dundee⁶⁶ is one of the top five European universities for excellence in research in biology, bio-chemistry, molecular biology and genetics. In the 2001 UK-wide RAE Dundee received the highest ranking of 5* in Biological Sciences, the only Scottish institution to do so. Amongst other achievements;

⁶⁶ <http://www.lifesci.dundee.ac.uk/home>

- Recognition of its environmental research has led to the formation of a UNESCO global project that is carrying out a situation assessment of the occurrence and impacts of toxic blue-green algal blooms in lochs, reservoirs and rivers throughout the world.
- Professor Sir Philip Cohen based at the College of Life Sciences, Dundee University, was frequently cited as a key source of commercial activity with current interests in pathogenic infection. Other cited income arose from Professors Sir David and Birgit Lane, Division of Molecular Medicine also at Dundee University. Dundee academics were instrumental in securing major investment for Dundee from Millipore centred on drug discovery and a German investment centred on microsurgery.

Aerospace, Defence and Marine: The University of Dundee is a leader in Space research. The university has expertise in satellites, space wire systems and robots. **STAR-Dundee Ltd.**⁶⁷ is a spin-out from the Space Systems Research Group of the University of Dundee. It is considered the most successful commercialisation activity of aerospace in Scotland, and the company has won several international contracts.

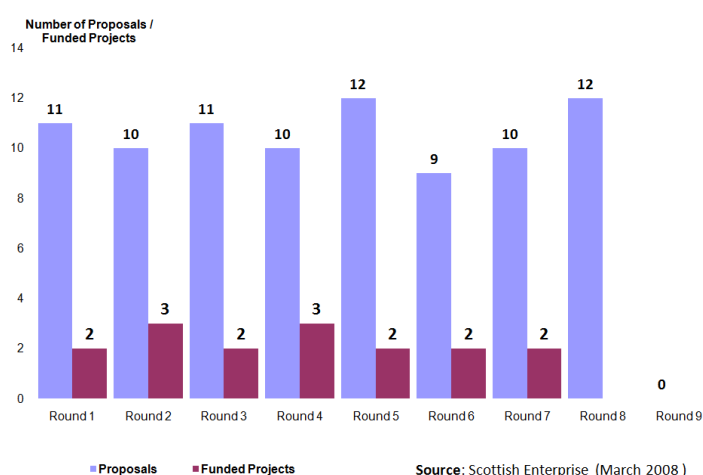
Chemical Sciences: The University of Dundee is very active in delivering research in chemical sciences, this research is however incorporated in its college of life sciences. Its prominence in chemical sciences research is reflected by:

- The University is not amongst the top five total research and grant contract income earners but is the fourth largest commercial and UK charities income earners in the chemical sciences accounting for up to 63% of the university's total research grants and contracts income; and
- Despite employing four times less the number of academic professionals in chemical sciences research than the University of St. Andrews, the University of Dundee still generates approximately 1.3 times more commercial and UK income than the University of St. Andrews.

Commercialisation

Figure 4.24: Number of Collaborations in Publications

University of Dundee has been relatively prolific in pursuit of Scottish Enterprise funding, under Proof of Concept, with 16 out of 73 proposals receiving funding to the end of Round 7. However the success rate is relatively poor, at just 21.9%, with no sign of improvement in later rounds, 6 and 7, when just four from 19 proposals were successful.



⁶⁷ www.star-dundee.com

The University has generated over 20 spinout companies and 3 associated start ups. Of the 20 spinouts, ten are associated with the Life Sciences sector and/or in respect of medical device companies. Of the 20 spinouts, 15 have emerged since 2000. The University estimates that spin-outs and start-ups and inward investment associated with its activities have created over 600 jobs in the local economy.

Key spin-out companies include Axis-Shield plc and Cyclacel, which now have international operations in Scandinavia and the United States, as well as retaining a substantial presence in Dundee.

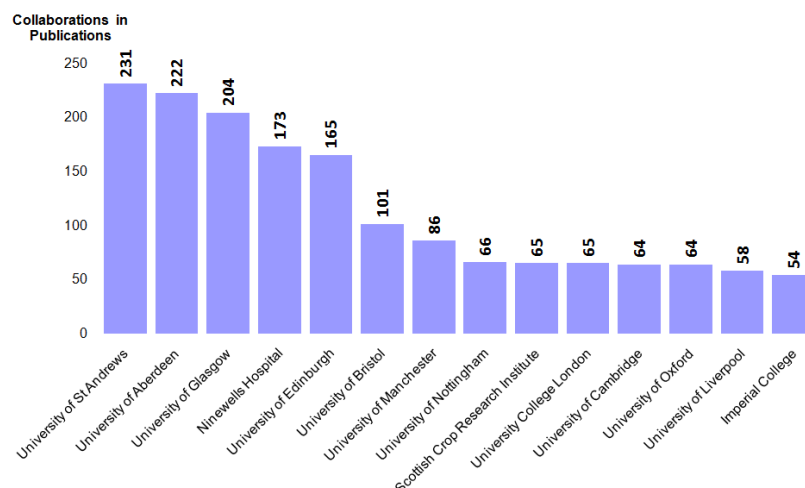
Dundee has had some significant success in generating patents, with 147 being recorded⁶⁸ between 2002 and 2006 and, as is the case for Aberdeen, Dundee generated more patents than the University of Edinburgh over the same period. The University asserts it has patents and patent applications covering 120 different technologies and earns over £1.4 million in licensing income from its licensed technologies. In the last 5 years the University estimates that it has earned almost £10 million from its Intellectual Property.

The University has established a dedicated KT and commercialisation team, research and Innovation Services⁶⁹, is responsible for the pre-award administration of research funding, costing research, advising on proposals, and negotiating contracts prior to projects starting. RIS also seeks to secure infrastructure funding to build the research capacity of the University.

Citations & Publications

University of Dundee received 275 citations in the World's seven foremost scientific⁷⁰ journals over the period 2000 to 2007, or 9.2% of the total of 2,990 for all Scottish research establishments. The university has produced an average of 1,021 published items per annum over the period 2000-2007 and had 8,281 abstracted papers over that period.

Figure 4.25: Number of Collaborations in Publications



Source: Thomson (Web of Science)

The top five key collaborators with whom Dundee work are all based in Scotland, i.e. St Andrews, Aberdeen, Glasgow, Edinburgh, Ninewells Hospital (Dundee). Other collaborations from the rest of the UK or overseas include: Bristol, Manchester, Nottingham, SCRI, University College London, Cambridge and Oxford.

68 UK Higher Education Research Yearbook 2007, Evidence Ltd

69 <http://www.dundee.ac.uk/research/main/about-ris/>

70 Proceedings of the Royal Society, Science, Nature, Proceedings of the National Academy of Sciences of the United States of America, British Medical Journal, The Lancet, and New England Medical Journal.

Table 4.5: High impact institutions – University of Dundee

Institution	Income and Expenditure £ million			Workforce			Delivery	*Rank
	Research Income (£million)	Commercial/ Charities Research Income (£ million)	Staff FTE	Research Only Staff FTE	Teaching and Research FTE	PhD Awards (Higher Degrees)	Most Common Publications and Citations	
Life Sciences	£37.2	£20.4	1,207	403	296	60 (150)	Biochemistry & molecular biology Cell biology Medicine, general and internal Pharmacology and pharmacy Oncology	3
Digital Markets & Enabling Technologies	£2.9	£0.2	274	50	101	n/a (85)	..	6
Chemical Sciences	£1.3	£0.8	29	13	9	n/a (0)	..	6
Construction	£1.3	£0.2	99	22	40	n/a (45)	..	2
All Subjects	£42.8	£21.0	3,059	506	708	110 (595)		4

Note: Due to industry definitions rows are not mutually exclusive. For example Physics contributes significantly in Energy, Digital Markets and Enabling technologies and Aerospace, Defence and Marine. Each row demonstrates the current potential resources relevant to each industry.

* Rank among other universities based on total research grants and contracts income in each priority industry

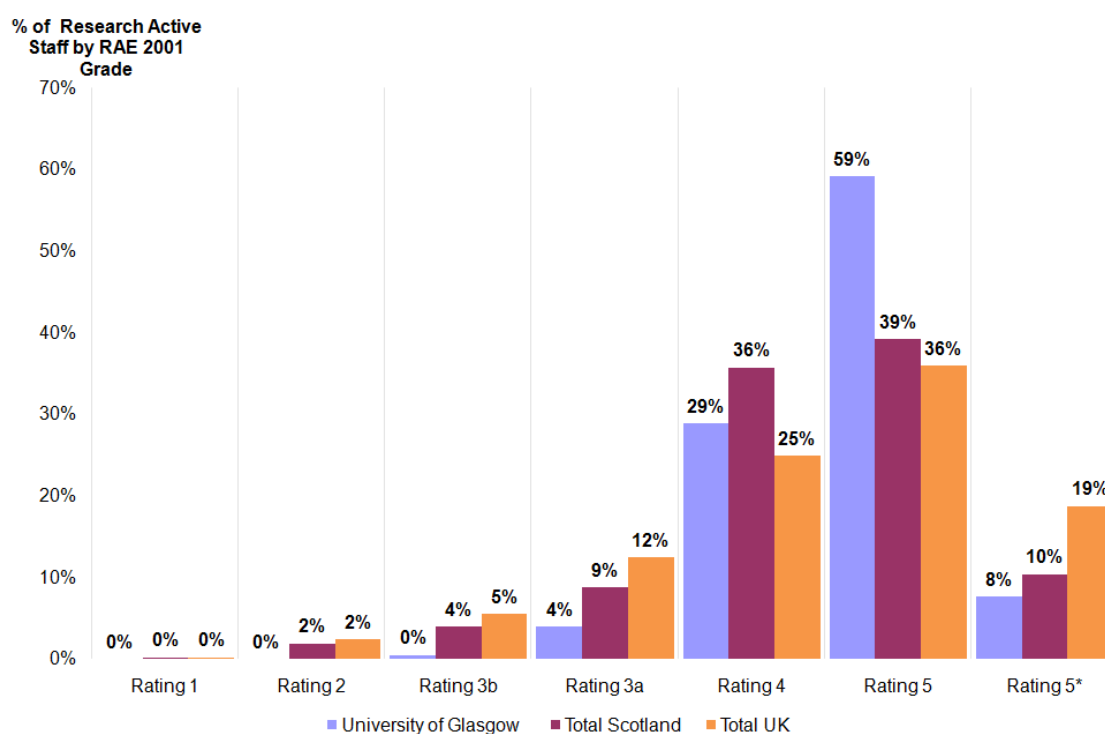
4.5 West

4.5.1 University of Glasgow

4.5.1.1 Research Quality

In the 2001 Research Assessment Exercise (RAE), the university gained a total of four 5* rated departments, of which just one (Psychology) is of any relevance to Priority Industries. However, in addition, Glasgow received 19 ratings at grade 5, of which 13 were related to Priority Industries (Clinical Laboratory Sciences, Hospital-based Clinical Subjects, Biological Sciences, Veterinary Science, Physics, Pure Mathematics, Applied Mathematics, Statistics and Operational Research, Computer Science, Electrical and Electronic Engineering, Mechanical, Aeronautical and Manufacturing Engineering, Town and Country Planning and Accounting and Finance).

Figure 4.26: Performance in the 2001 Research Assessment Exercise



This is a particularly strong performance, which is reflected in the chart above, showing that, in total, 67% of research active staff were working in 5 or 5* rated departments. The university had a further 20 awards at grade 4, of which nine relate to priority industries, including subjects such as Community-based Clinical Subjects, Chemistry, Earth Sciences, Civil Engineering, Mechanical, Aeronautical and Manufacturing Engineering (Aerospace Engineering and, separately, Naval Architecture), Economic and Econometrics, Business and Management Studies, and Music.

Total Research Income

The University of Glasgow is, in a Scottish context, the second largest university in terms of total research income, with £110.8 million in 2005/06, and evidence of further growth since that date.

Some 32% of all research income comes from Scottish Funding Council recurrent grants, which is similar to the sector average for Scotland (33%). Similarly to Edinburgh, the University's strength in subjects of significance to Life Sciences and its success in the

RAE 2001, the University draws in a significant proportion (23.1%) of its income from OSR Research Councils, such as the Medical Research Council, and 22.8% from UK based charities, including those funding research into cancer and neural conditions.

In total, the University raised almost £51 million from these two sources alone, and a further £9 million from public sources such as NHS Hospital Trusts. The University raised £5.5 million from UK commercial sources, which was close behind sums raised by Edinburgh and Strathclyde.

In terms of key subjects that are of relevance to the Priority Industries, Clinical medicine draws in £27.4 million in funding for research contracts, some 28% of the total for Scotland (close behind Edinburgh which takes 36%) in that subject and features the world renowned Beatson Institute. Biosciences is the next most significant in scale (£14.3 million and 18% of the Scottish total), while research in areas such as Veterinary Science (£5.7 million and 40%) and Physics (£5.6 million and 19%) are also key to the University.

Health and Community studies, although small in scale (£2.1 million) is an area where Glasgow accounts for more than half (54%) of all research in Scotland for the subject. Mathematics at £1.9 million (30%) is relatively significant for the University, and the Robertson Centre for mathematical research plays a pivotal role in supporting the analysis of results from clinical trials for the Scottish Life Sciences sector.

Figure 4.27: Total Research Income Attained in 2005/06

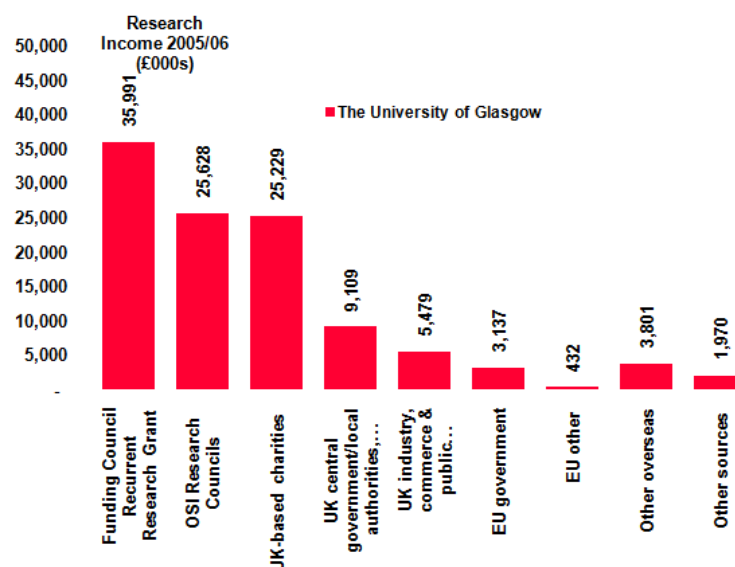
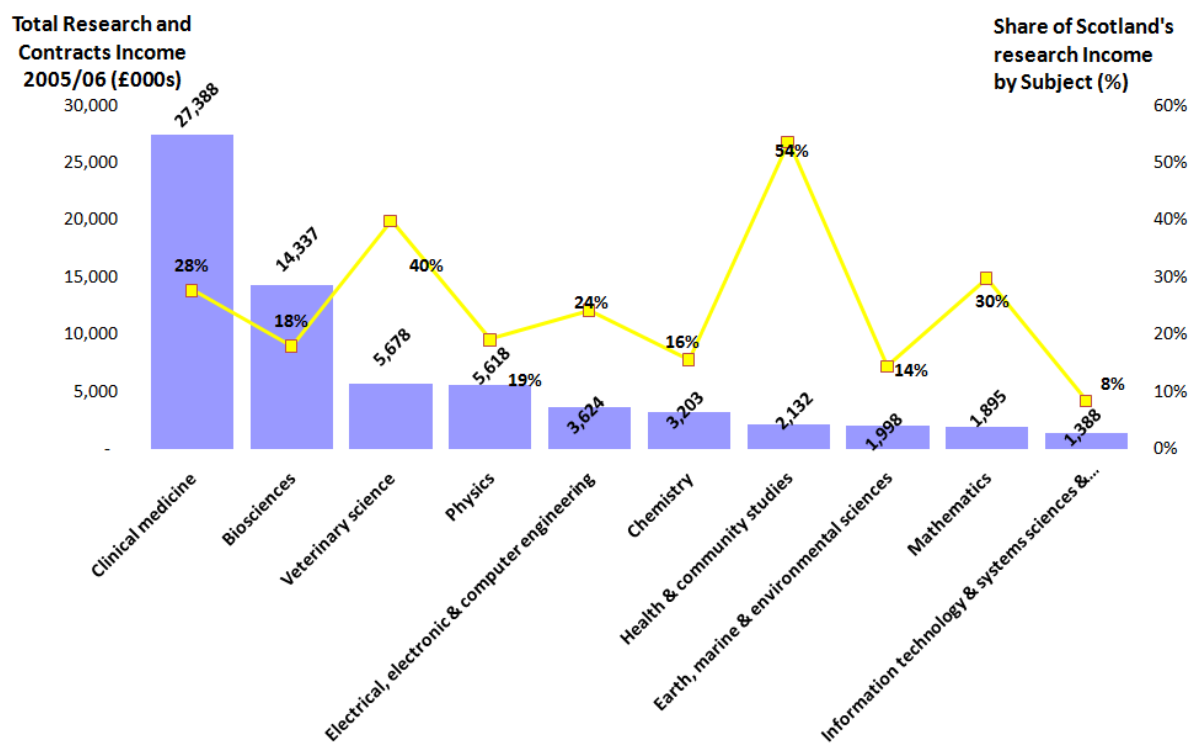


Figure 4.28: University of Glasgow: Top Priority Industry-related Research, by Subject, 2005/06: Total Research Contracts Income and Share of Total in Scotland for Subject



Source: HESA Resources in HE Institutions; adapted by DTZ

Priority Industries

Life Sciences: The University of Glasgow is the second most significant player in life sciences research grants and contracts income with £50.3 million in (2005-06) or 24% of the total for Scotland. Life Sciences accounts for 67% of all research grants and contracts income for the University. University of Glasgow is particularly strong in terms of research relating to oncology. While Edinburgh's strength is seen as being in the 'basic or blue skies research', Glasgow has carved out a particular role in applied research, e.g. through the work of the Tumour Suppression Unit of the Beatson Institute.

University of Glasgow is a key player in both the Scottish Universities Life Sciences Alliance (SULSA) and the Translational Medicine Research Collaboration (TMRC)⁷¹. Glasgow's strength in applied research, is perhaps the principal reason why Glasgow receives more than half (£26.7 million) of all its research grants and contracts income for Life Sciences from commercial or UK charitable sources, although just £5.5 million was from commercial sources.

⁷¹ See Life Sciences section for other members

- **Glasgow Centre for Cancer Research:** The World-famous Beatson Institute⁷², a registered charity, works very closely with the University in pursuit of understanding key aspects of cancer cell behaviour, and tries to translate these discoveries into new therapies and diagnostic/prognostic tools to help cancer patients. Both University of Glasgow's own and Beatson Institute's cancer research staff are now co-located at the Centre.
- The **Department of Biochemistry and Cell Biology**⁷³ is headed by Professor Richard Cogdell FRS, and research includes: **protein science**, i.e. understanding the molecular details of how proteins function, with research being well-supported by grants from BBSRC, Wellcome Trust, EU and Industry; and **cell biology**, housed within the Henry Wellcome Laboratory of Cell Biology, the Glasgow Cell Biology group consists of some 25 scientists, with grant income of almost £4 million, and research directed toward a molecular understanding of fundamental areas of cell biology including membrane traffic, cytokinesis and compartmentalisation of cellular signalling.
- The **Robertson Centre for Biostatistics**⁷⁴ is an essential part of the Scottish Life Sciences research pool and facilitates high-value clinical studies. University of Glasgow claim the Centre is responsible for data analysis for some 70% of clinical trial results in Scotland, with particular success in areas such as cardiac and cardiovascular systems; peripheral vascular disease; clinical neurology and haematology.
- **British Heart Foundation Glasgow Cardiovascular Research Centre**⁷⁵ is home to approximately 150 research and technical staff in total, with Professor Anna Dominiczak as Director. The Centre has state-of-the-art clinical research facilities, physiology and electrophysiology laboratories, well equipped molecular laboratories with facilities for human and experimental genetics, genomics and proteomics including high throughput SNP genotyping, gene expression profiling, vascular gene transfer/therapy and many other modern molecular technologies.
- The **Department of Human Nutrition**⁷⁶ collaboration between science, medicine-based and other departments. There are 3 main laboratory sites: GRI (mainly adult medicine, facilities shared with other University and clinical departments; Yorkhill (mainly infant and children and shared with Child Health and other Yorkhill departments); and Gilmorehill campus Stevenson Laboratory (Plant Products and Human Nutrition Research Group shared with Ecology and Evolutionary Biology).

The University has some 366 staff working exclusively in research relating to Life Sciences, with a further 460 working in both teaching and research. The latter group is relatively large, as a component of the total Life Sciences research community at the University.

⁷² <http://www.beatson.gla.ac.uk/>

⁷³ <http://www.gla.ac.uk/departments/biochemistrycellbiology/>

⁷⁴ <http://www.rcb.gla.ac.uk/>

⁷⁵ <http://www.gla.ac.uk/bhfgcra/>

⁷⁶ <http://www.gla.ac.uk/departments/humannutrition/research/>

Digital Markets and Enabling Technologies: Glasgow University Electronics and Electrical Engineering (EEE) Department has held one of the top positions in the RAE for the last 15 years and has more citations for published research than any other UK EEE department. The department, headed by Professor John Arnold currently has a research grant portfolio of over £28m. Within this, total research grants and contracts income (i.e. excluding SFC recurrent research grant) relating to this sector was £11.0 million in 2005/06.

Key research collaborations include work with Strathclyde on the Institute of Photonics, as well as ISLI.

- The Institute for System Level Integration (ISLI)⁷⁷ is an academic collaborative venture between Glasgow, Edinburgh, Heriot-Watt and Strathclyde universities as well as ISLI Ltd and SE. ISLI research activities are in the areas of system design and system on chip technology.

Energy: The main areas of research of relevance are through the University's Department of Physics & Astronomy and its Institute for Gravitational Research. To-date, Glasgow has not been engaged in any of the SUPERGEN workstreams.

Aerospace, Defence and Marine: Glasgow and the West of Scotland are recognised as a leading world centre for commercial ship management. The **Department of Naval Architecture and Marine Engineering** (NAME) is a joint department of the Universities of Glasgow and Strathclyde. They represent the principal research that is taking place, and is one of the premier providers of teaching and research in Naval Architecture and its related disciplines. Main research interests lie in ship stability and safety, marine hydrodynamics, marine structures, ocean engineering, marine engineering and emerging technologies.

Chemical Sciences: Professor David Jacobson is known to have strong links to ICI, and GSK, with many PhD students based in Glasgow, and research relating to the sector drew in more than £3.2 million in research grants and contracts income in 2005/06. Professor Chris Gilmour of the University is Chairman of the pan-Scotland research pooling group, SCOTCHEM. Glasgow's strengths include bio molecular chemistry⁷⁸, structure and materials (synthesis, characterisation, modelling, and application)⁷⁹ and synthesis of natural products⁸⁰. Glasgow and University of Strathclyde have formed the regional consortium, WestCHEM⁸¹, within the SCOTCHEM framework.

Commercialisation

In the period 2002/03 to 2006/07, the University generated a total of 21 spin outs⁸². Nine of these spin-outs were created in 2006/07.

⁷⁷ <http://www.sli-institute.ac.uk>

⁷⁸ <http://www.chem.gla.ac.uk/research/sections/BioMol/>

⁷⁹ <http://www.chem.gla.ac.uk/research/sections/StructMats/>

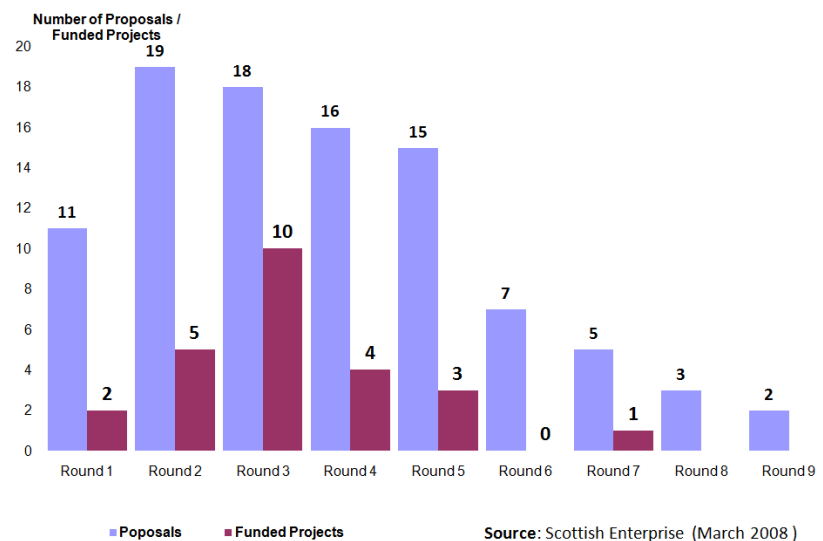
⁸⁰ <http://www.chem.gla.ac.uk/research/sections/Synthesis/>

⁸¹ <http://www.westchem.ac.uk/>

⁸² <http://www.gla.ac.uk/research/aimsassessmentandpolicies/howwemeasureourselves/keystatistics2002-7/>

University of Glasgow has been particularly active in pursuit of Scottish Enterprise funding, under Proof of Concept, with 25 out of 91 proposals receiving funding, i.e. a 27.5% success rate, which is lower than that achieved at Edinburgh (35.8%). It is notable that in rounds 6 and 7, the success rate dropped dramatically to just 1 success out of 12 proposals (8.3%).

Figure 4.29: PoC Proposals / Funded Projects



High profile University of Glasgow spin outs include:

- **Crucial Genetics**, a state-of-the-art genetic profiling service. The company is based in customised laboratory facilities at the Southern General Hospital and is equipped with the latest automated fluorescent DNA laser scanning machinery.
- **Crusade Laboratories** was founded in December 1999 as a joint venture company between a Venture Capital Group, Glasgow University, and Cancer Research Ventures expressly to expand and accelerate the basic and clinical research of Professor Moira Brown and her team at the University of Glasgow, with work based at the Southern General Hospital. Crusade is pursuing the development of variants of Herpes Simplex Viruses (HSV) for the novel treatment of cancers.
- **Diagnostic Potentials** commenced operations in July 1999 and concentrates upon developing a range of diagnostic and monitoring systems for Central Nervous system (CNS) disease states. The first product that has been developed is ADEPT, a system for the early diagnosis of Alzheimer's disease that will assist clinical consultants to make a positive decision on the care of the patient and on the prescribing of drugs.
- **Dimensional Imaging**, previously known as Virtual Clones, was established in 2003 as a spin-out company from Glasgow and University of Edinburgh to exploit virtual character creation technology developed at both universities. This new company provides advanced 3D and "4D" surface image capture solutions for medical, entertainment and other applications.

The Glasgow commercialisation group works with the IP Group, structured whereby senior level figures at the University decide to go ahead with a project and handover to IP. There is a particular focus on early stage technologies and they attract other investment as appropriate. There have been only a couple of spin-outs based upon this model, but is an early initiative and it is hard to judge the long term effect.

There are issues with internal resources and skills within the IP Group. The group has the potential to release the logjam, but Strathclyde has more experience in this area. Glasgow would need to up-skill the group for other areas of commercialisation.

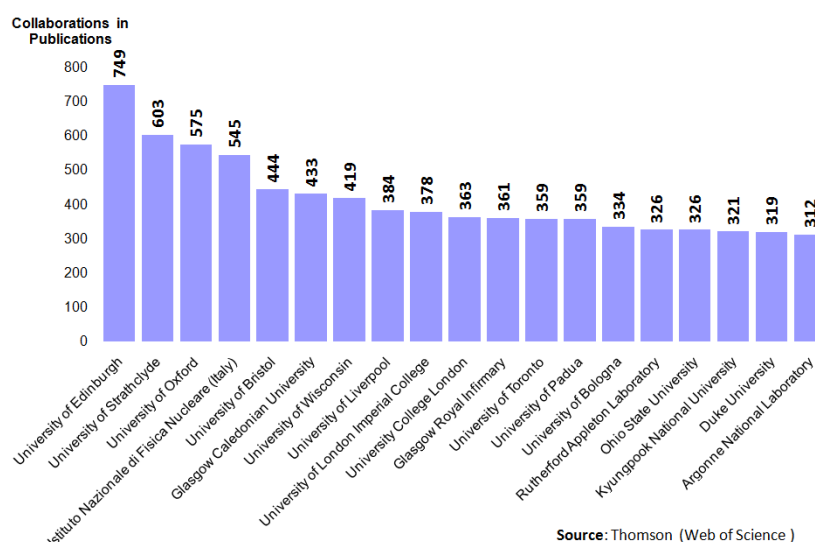
Glasgow has had greater success than University of Edinburgh in generating patents, with 194 being recorded⁸³ between 2002 and 2006 (compared with 133 for Edinburgh), and a total of 441 patents in force by 2006/07, although total royalties⁸⁴ in 2006/07 were just £0.8 million, having been £1.7 million in 2002/03. A total of 105 licences were agreed over this period.

Knowledge transfer funding has increased steadily over the period 2002/03 to 2006/07, from £1.0 million to £3.3 million per annum.

Citations & Publications

University of Glasgow received 522 citations in the world's seven foremost scientific⁸⁵ journals over the period 2000 to 2007, or 17.5% of the total of 2,990 for all Scottish research establishments. The university has produced an average of 2,487 published items per annum over the period 2000-2007 and had 20,215 abstracted papers over that period.

Figure 4.30: Number of Collaborations in Publications



Source: Thomson (Web of Science)

Key collaborations include Edinburgh, Strathclyde and Glasgow Caledonian, but also several rest of UK or international academic partners such as Oxford, INFN (Italy), Wisconsin, Imperial College, Toronto, Padua, Bologna, Ohio State, Kyungpook National University (South Korea) and Duke University (US).

In life sciences, the University is heavily involved with NHS clinical trials, which explains the presence of Glasgow Royal Infirmary within the top 20 collaborations. Not listed is the involvement of Wyeth Pharmaceuticals who are working together with Glasgow and the University of Aberdeen. The largest and highest value collaboration is the project on translational medicine together with University of Dundee and University of Edinburgh, although Dundee too does not yet feature in the top 20 collaborative partners in terms of publications.

83 UK Higher Education Research Yearbook 2007, Evidence Ltd

84 <http://www.gla.ac.uk/research/aimsassessmentandpolicies/howwemeasureourselves/keystatistics2002-7/>

85 Proceedings of the Royal Society, Science, Nature, Proceedings of the National Academy of Sciences of the United States of America, British Medical Journal, The Lancet, and New England Medical Journal.

Table 4.6: High impact institutions – University of Glasgow

Institution	Income and Expenditure £ million			Workforce			Delivery	*Rank
	Research Income (£million)	Commercial/ Charities Research Income (£ million)	Staff FTE	Research Only Staff FTE	Teaching and Research FTE	PhD Awards (Higher Degrees)	Most Common Publications and Citations	
Life Sciences	£50.3	£26.7	1,443	366	466	150 (295)	Biochemistry & molecular biology; Genetics and heredity; Neurosciences; Cell biology; Ecology; Evolutionary biology	1
Energy	£14.8	£1.4	536	146	174	99 (115)	Applied physics / Materials science	1
Digital Markets & Enabling Technologies	£11.0	£0.5	463	114	181	n/a (175)	..	1
Aerospace, Defence and Marine	£11.5	£1.2	420	119	131	n/a (85)	..	1
Chemical Sciences	£3.2	£0.1	94	26	33	n/a (15)	..	2
Financial Services	£2.9	£0.4	183	15	99	n/a (250)	..	5
All Subjects	£74.8	£30.7	4,681	649	1,266	340 (1,310)		2

Note: Due to industry definitions rows are not mutually exclusive. For example Physics contributes significantly in Energy, Digital Markets and Enabling technologies and Aerospace, Defence and Marine. Each row demonstrates the current potential resources relevant to each industry.

* Rank among other universities based on total research grants and contracts income in each priority industry

4.5.2 University of Strathclyde

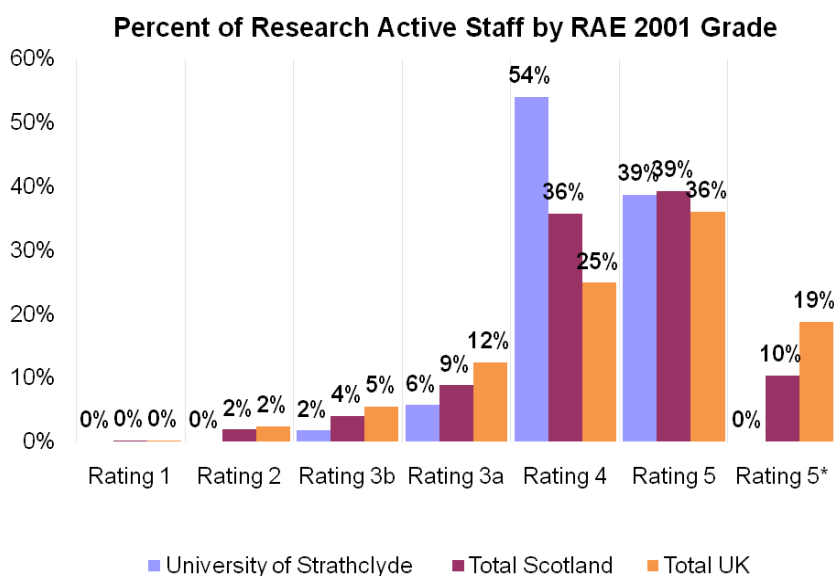
The University of Strathclyde has carved out a high profile in terms of applied research.

In the 2001 Research Assessment Exercise (RAE), the university did not gain any 5* grades.

However, Strathclyde did receive ten ratings at grade 5, of which seven were related to Priority Industries (Pharmacy, Other Studies and Professions Allied to Medicine, Applied Mathematics, General

Engineering, Electrical and Electronic Engineering, Mechanical, Aeronautical and Manufacturing Engineering and Accounting and Finance).

Figure 4.31: Performance in the 2001 Research Assessment Exercise



This relative concentration of scores on grade 5 is reflected in the chart above, showing that 39% of research active staff were working in 5 or 5* rated departments (all were 5-rated in practice). This is significantly below the national average (49%). However, the University had a further 16 awards at grade 4, of which nine relate to priority industries (Psychology, Chemistry, Physics, Statistics and Operational Research, Civil Engineering, Mechanical, Aeronautical and Manufacturing Engineering, Built Environment, Economics and Econometrics, Business and Management Studies).

Total Research Income

The University of Strathclyde attracts the fifth largest amount of research income among Scotland's universities in terms of total research income, with £46.6 million in 2005/06.

Some 26% of all research income comes from OSR Research Council grants, while 38% of all research income comes from Scottish Funding Council recurrent grants, i.e. above the sector average for Scotland (33%).

The University attracts relatively little income from UK-based charities (5.4% compared with 16% nationally), but does receive a relatively high proportion of income from UK commercial concerns (12.4% versus 5.8% for Scotland) and EU government funding, e.g. Framework VII (7.5% compared with 4.7% for Scotland). This indicates that the research is relatively commercial in orientation and therefore it may have a disproportionate impact upon economic growth. In total, the University raised almost £9.2 million from these two sources alone.

In terms of key subjects that are of relevance to the Priority Industries, Electrical, Electronic and Computer Engineering draws in £4.8 million in funding for research contracts, some 32% of the total for Scotland in that subject, with Strathclyde being a key player in ISLI for example. Physics is the next most significant in scale (£4.7 million and 16% of the Scottish total), while research in areas such as Mechanical, Aerospace and production engineering (£4.4 million and 55% of the total for Scotland), Chemistry (£3.8 million, or 18%) and Pharmacy and Pharmacology (£3.2 million, or 70% of the total for Scotland) are all key to the University and significant at a Scotland level.

Figure 4.32: Total Research Income Attained in 2005/06

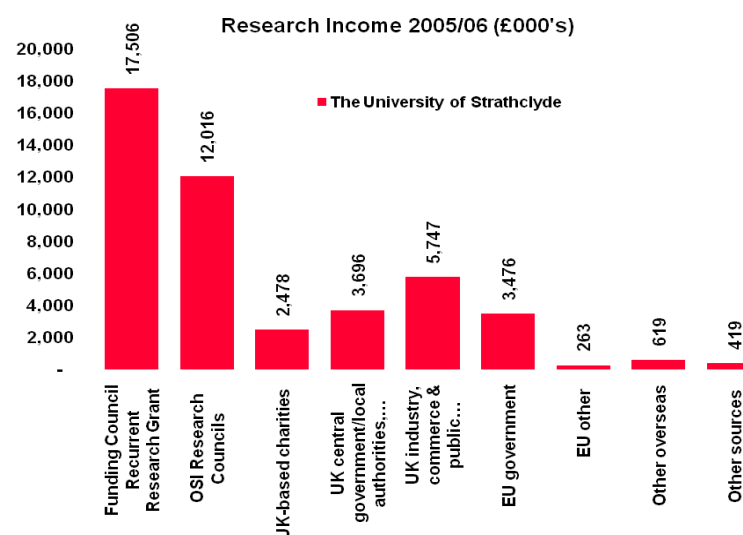
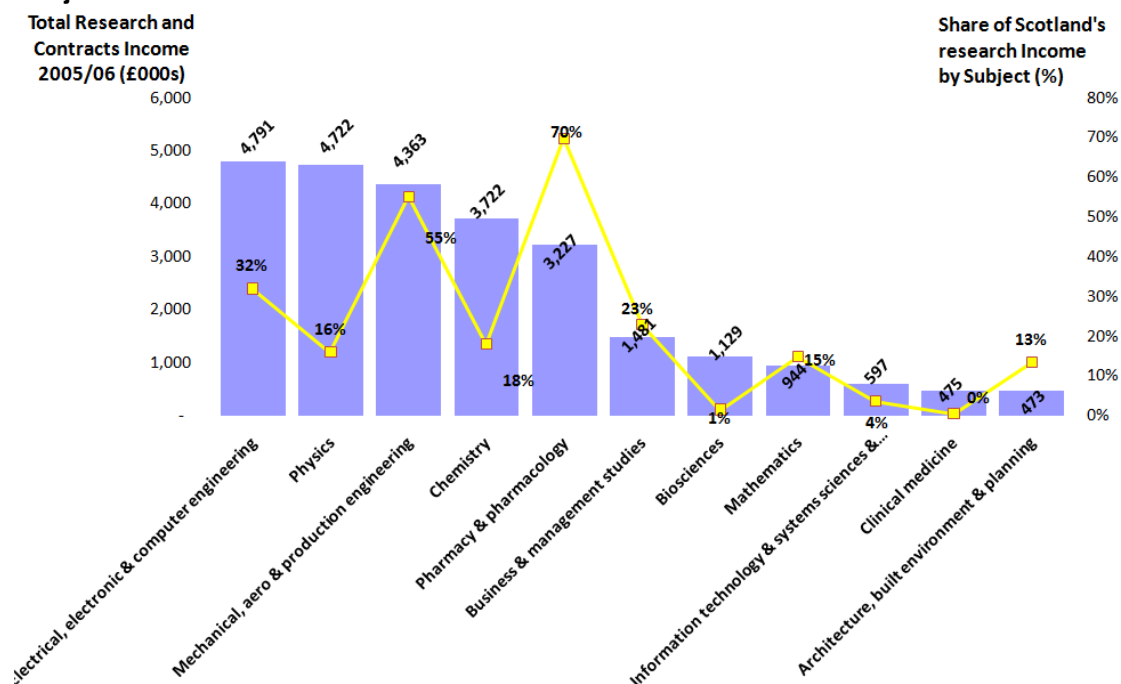


Figure 4.33: University of Strathclyde: Top Priority Industry-related Research, by Subject, 2005/06: Total Research Contracts Income and Share of Total in Scotland for Subject



Source: HESA Resources in HE Institutions; adapted by DTZ

Priority Industries

The University of Strathclyde is the:

- Highest recipient of total research grants and contracts income in the chemical science industry and the second highest recipient in the tourism, financial services, energy, digital markets and enabling technologies and the aerospace, defence and marine industries.
- Highest recipient of total commercial and UK charities income in the chemical science, energy, digital markets and enabling technologies and enabling technologies and the aerospace, defence and marine industries.

Life Sciences: The University of Strathclyde is the sixth highest earner of total research grants and contracts income (£5.3 million) in the life sciences. Over half of this (£2.7 million) is generated through commercial and UK charities income. In addition:

- The Strathclyde Institute of Medical Devices⁸⁶ is a leader in new medical products development and has strong company linkages, e.g. with Lifescan / Johnson & Johnson.

⁸⁶ <http://www.strath.ac.uk/simd/>

Energy: The University of Strathclyde is the second biggest total research grant and contract income (£18.2 million), accounting for 19% of the total research grants and contract income earned by Scottish universities. Features of its work are as follows:

- The university is the highest total commercial and UK charities income recipient amongst Scottish universities.
- “The University of Strathclyde is part of the **SUPERGEN Marine Energy Research Consortium**⁸⁷, the **SUPERGEN Future Network Technologies Consortium** and the **SUPERGEN Highly Distributed Power Systems Consortium**”.
- The University of Strathclyde’s department of physics and the Institute of Photonics are part of the Scottish Universities Physics Alliance (SUPA). SUPA’s concept is to build the alliance around key research strengths on which there is multi-institutional agreement (See Energy section)
- **Professor Jim McDonald**, deputy principal at Strathclyde University is among the key individuals identified by the SE energy team as leaders in energy research.

Digital Markets and Enabling Technologies: The University of Strathclyde is a key research player in the digital markets and enabling technologies industry receiving the second biggest amount of total research grants and contracts income amongst Scottish universities (£14.5 million) and is the highest recipient of total commercial and UK charities income (£3.5 million). It is also notable that:

- The university’s Institute of Photonics⁸⁸ is a key academic centre in research in the digital markets and enabling technologies industry. Its research interests include semiconductor materials and devices, practical, all solid state lasers, micro-LED arrays and a wide range of applications particularly in biophotonics. The Institute has leveraged over £16 million in competitively won grants and contracts and currently holds the 4th largest portfolio of EPSRC grants in the University, worth over £6m.

Aerospace, Defence and Marine: The University of Strathclyde is the second biggest total grants and contracts income recipient (£13.9 million) and the highest total commercial research and UK charities income recipient. Also of note is that:

- The university is part of the **Glasgow Research Partnership in Engineering (GRPE)**⁸⁹, a research collaboration body between Universities of Glasgow, West of Scotland (previously Paisley), Glasgow Caledonian and Strathclyde. The partnership’s focus is on research enhancement and commercialisation in order to position the West of Scotland as a major world centre for Engineering (See Aerospace, defence and Marine section).

⁸⁷ <http://www.epsrc.ac.uk/ResearchFunding/Programmes/Energy/Funding/SUPERGEN/MarineEnergyResearch.htm>

⁸⁸ <http://www.strath.ac.uk/Departments//Photonics/welcome.html>

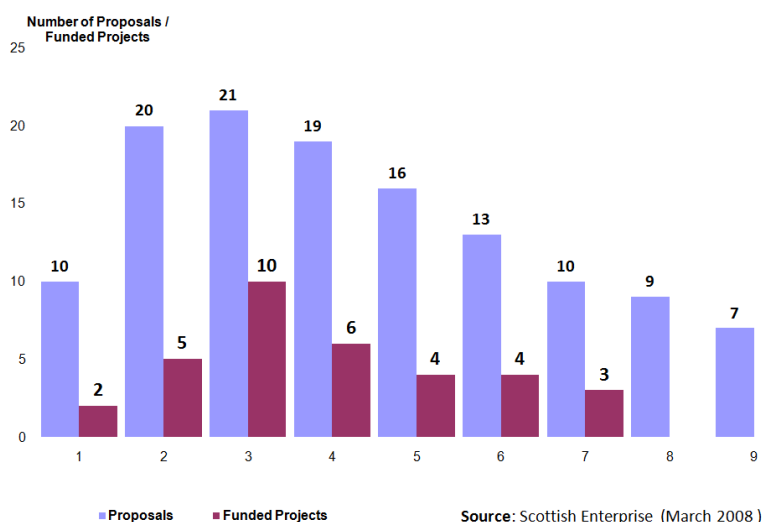
⁸⁹ www.grpeng.ac.uk

Chemical Sciences: The University of Strathclyde is the highest total research grants and contracts income (£7.3 million) as well as total commercial and UK charities income (£3.2 million) recipient amongst Scottish universities.

Commercialisation

University of Strathclyde has been prolific in pursuit of Scottish Enterprise funding, under Proof of Concept. In total, 34 of 109 proposals received funding over the first seven rounds of the fund. Strathclyde has a relatively good success rate too, at 31.1%. However, in rounds 6 and 7, there were signs that, although the hit rate remained good, the number of proposals generated had slipped back significantly, as demonstrated in the adjacent chart.

Figure 4.34: PoC Proposals / Funded projects



The University prides itself that it is “*leading the way in developing new drugs to tackle the diseases of the 21st Century, and advanced renewable energy technologies for the power industries.*”⁹⁰

Strathclyde has had some significant success in generating patents, with 151 being recorded⁹¹ between 2002 and 2006 and, as is the case for Aberdeen and Dundee, Strathclyde generated more patents than the University of Edinburgh over that period.

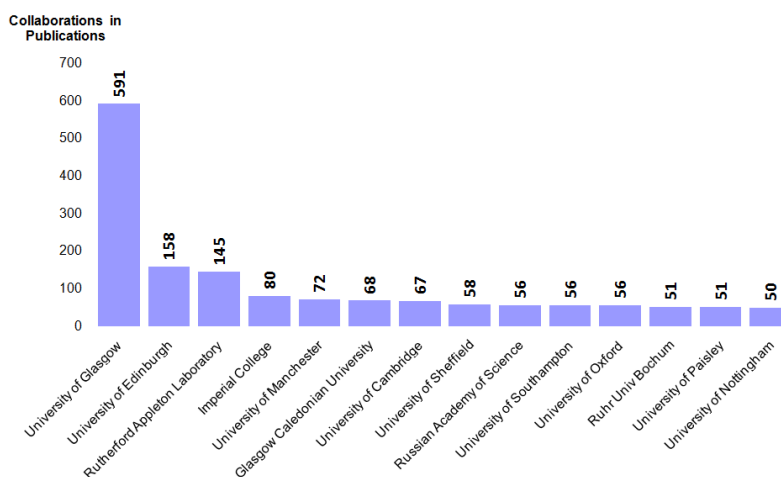
⁹⁰ <http://www.strath.ac.uk/research/>

⁹¹ UK Higher Education Research Yearbook 2007, Evidence Ltd

Citations & Publications

University of Strathclyde received just 25 citations in the world's seven foremost scientific⁹² journals over the period 2000 to 2007, or 0.8% of the total of 2,990 for all Scottish research establishments. However, the university has produced an average of 869 published items per annum over the period 2000-2007 and had 7,056 abstracted papers over that period.

Figure: 4.35: Number of Collaborations in Publications



Source: Thomson (Web of Science)

As is clear from the chart above, the University of Glasgow was by far the most significant research collaborator for Strathclyde. Somewhat behind Glasgow were the University of Edinburgh, Rutherford Appleton Laboratory (near Oxford⁹³), Imperial College and the University of Manchester. The University also collaborates with the University of Cambridge and the Russian Academy of Science.

⁹² Proceedings of the Royal Society, Science, Nature, Proceedings of the National Academy of Sciences of the United States of America, British Medical Journal, The Lancet, and New England Medical Journal.

⁹³ Specialising in research in astronomy, particle physics, space science and nuclear physics

Table 4.7: High impact institutions - Strathclyde

Institution	Income and Expenditure £ million			Workforce			Delivery Most Common Publications and Citations	*Rank
	Research Income (£million)	Commercial/ Charities Research Income (£ million)	Staff FTE	Research Only Staff FTE	Teaching and Research FTE	PhD Awards (Higher Degrees)		
Life Sciences	£5.3	£2.7	334	75	117	25 (110)	Pharmacology and pharmacy	6
Energy	£18.2	£4.7	714	235	216	98 (320)	Energy and Fuels	2
Digital Markets & Enabling Technologies	£14.5	£3.5	612	208	190	n/a (400)	Engineering, electric and electronic, Optics, Physics, applied Materials science, multidisciplinary	2
Aerospace, Defence and Marine	£19.7	£2.4	561	164	175	n/a (115)	-	2
Chemical Sciences	£7.3	£3.2	292	81	90	n/a (100)	Chemistry	1
Financial Services	£2.4	£0.3	268	22	126	n/a (575)	-	2
Construction	£0.7	£0.1	62	5	31	n/a (35)	-	4
All Subjects	£28.7	£8.2	3,090	397	801	175 (1,430)	-	5

Note: Due to industry definitions rows are not mutually exclusive. For example Physics contributes significantly in Energy, Digital Markets and Enabling technologies and Aerospace, Defence and Marine. Each row demonstrates the current potential resources relevant to each industry.

* Rank among other universities based on total research grants and contracts income in each priority industry

5. Activity of Research Institutes

Table 5.1: Summary table of Scottish Research Institutes

Name	Location(s)	Areas of Specialism	Priority Industries
Centre for Ecology and Hydrology	Edinburgh	Environment	
Fisheries Research Service	Aberdeen and Pitlochry	Freshwater and marine fish species	Food and drink
Forest Research	Edinburgh	Forest research	Forestry
Hannah Research Institute	Ayr	Dairy – now subsumed into University of Glasgow	Food and drink
Macaulay Land Use Research Institute	Aberdeen	Environment	
Moredun Research Institute	Edinburgh	Animal Health	Food and drink
Rowett Research Institute	Aberdeen	Animal & Human Nutrition – to become part of University of Aberdeen	Food and drink
Royal Botanic Garden	Edinburgh	Plants	
Scottish Agricultural College	Edinburgh, Aberdeen, Ayr	Animal Welfare	Food and drink
Scottish Crop Research Institute	Dundee	Edible crops	Food and drink
Scottish Agricultural Science Agency	Edinburgh	Potatoes – now closed	Food and drink
Roslin Institute	Edinburgh	Animal nutrition and genetics – now part of University of Edinburgh	Food and drink Biotech
Institute for Animal Health – Neuropathogenesis Unit	Edinburgh	Animal and human health	

Table 5.2: Location, key contacts and research strengths of research institutes

Name and address	Key contact	Research strengths	Other
Centre for Ecology and Hydrology Bush Estate, Penicuik, Midlothian EH26 0QB edinburgh@ceh.ac.uk www.ceh.ac.uk	Dr J. Neil Cape	Four Science Programme:  Biodiversity  Water  Biogeochemistry  Environmental Informatics Two Cross-cutting Themes:  Climate Change  Sustainable Economies	Edinburgh is one of six sites across the UK. Edinburgh research focuses on the science underpinning air pollution and climate change. There is also work on sustainable land use and exploitation of new technologies in the tropics.
Fisheries Research Service FRS Marine Laboratory PO Box 101 375 Victoria Road Aberdeen AB11 9DB www.marlab.ac.uk/	Robin Cook, Director	Science at Fisheries Research Services (FRS) is conducted to facilitate the provision of advice to the Scottish Government and also to a range of Government departments. FRS' science programme can be broadly categorised into research, monitoring and advice. <ul style="list-style-type: none"> • Understanding the functioning of aquatic ecosystems • Understanding and quantifying human impacts on aquatic ecosystems, particularly on living resources and the aquatic environment • Evaluating options for sustainable fishing and aquaculture. 	FRS has important monitoring and advice roles in relation to marine and freshwater environment and species.
Forest Research Northern Research Station	David Clark	Environmental research Researching the relationships between the physical and historic environments and woodlands and developing establishment and management practices for farm and	

Roslin
Midlothian EH25 9SY
nrs@forestry.gsi.gov.uk

brownfield woodlands.



Pathology

Investigating instances of damage, determining the cause and developing control measures or management strategies for trees in all settings.



Silviculture

Understanding and manipulating forest establishment, composition and growth from developing seed to mature tree and developing silvicultural techniques for sustainable forest management.



Social research

Understanding how forests and woodlands contribute to society and how forestry affects people's lives.



Technical development

Evaluating and developing forestry methods and machinery for greater efficiency, improved ergonomics and safety and reduced environmental impact.



Technical services

Providing technical and environmental expertise and services to scientists, woodland managers and land based industries.



Tree improvement

Increasing the genetic quality of planting stock.



Woodland ecology

Providing an ecological basis for the multi-purpose management of forests and woodlands and developing and encouraging the adoption of sustainable management practices.

Hannah Research Institute

Research activity at Hannah was moved to Strathclyde University, Glasgow Caledonian University and the Rowett Institute in 2005. The site is now being redeveloped with the proceeds to be used to fund agricultural research elsewhere.

www.hannahresearch.org.uk

Macaulay Land Use Research Institute

Craigiebuckler
Aberdeen
AB15 8QH

www.macaulay.ac.uk

Richard Aspinall –
Chief Executive
(science contact)

Neil Lindsay
(commercialisation
contact)

Catchment Management

- Comprehend how pollutants move through the environment
- Impact of pollutant transfers on soil and water ecology
- Develop tools and methodologies to help predict how human activities might affect the environment
- Provide the scientific underpinning to help develop and implement public policy.

		<p>Ecology</p> <ul style="list-style-type: none"> • Population ecology • Community ecology <p>Integrated Land Use Systems Group (ILUS)</p> <ul style="list-style-type: none"> • Agent based social modelling • Farm household modelling • Integrated landscape modelling • Visualisation techniques <p>Socio-Economic Research Group (SERG)</p> <ul style="list-style-type: none"> • Society institutions and governance • Rural and regional economics • Values, choices and behaviour <p>Soil</p> <ul style="list-style-type: none"> • Soil microbiology and biology • Soil science • Molecular biology • Mineralogy • Plant physiology. 	
<p>Moredun Research Institute Pentlands Science Park Bush Loan Penicuik Midlothian EH26 0PZ info@moredun.ac.uk</p>	<p>Professor Julie Fitzpatrick - Director</p>	<p>Bacteriology</p> <ul style="list-style-type: none"> • Bacterial infections • Molecular pathogenesis • Host bacterial infections <p>Parasitology</p> <ul style="list-style-type: none"> • Immunopathogenesis • Parasite control <p>Virology</p> <ul style="list-style-type: none"> • Virokines 	<p>MRI was established in 1920 by the Animal Diseases Research Association, now the Moredun Foundation, a charity dedicated to the improvement of animal health and wellbeing through research. The Institute is now a charitable company separate from,</p>

		<ul style="list-style-type: none"> Viral pathogenesis 	but subsidiary to, the Foundation.
Rowett Research Institute Greenburn Road Bucksburn Aberdeen AB21 9SB	Dr Sue Bird / Dr Alan Rowe	<ul style="list-style-type: none"> Developing an understanding of the biological activity of specific nutrients at a cellular level The identification and development of biomarkers to aid in the detection and prevention of diet-related diseases Understanding the basis of individual differences in responses to diet. <p>Fatty acids in the diet - mechanisms of action Folic acid fortification Gut health: 'friendly' gut bacteria and immune response Nutrition during pregnancy: and the health of the offspring Adolescent pregnancy and low birth weight</p>	Merger with Aberdeen University is currently at an advanced stage of negotiation – will create a new Institute of Nutrition and Health.
Royal Botanic Garden 20A Inverleith Row Edinburgh EH3 5LR		<p>Discovering and describing plants and their relationships, evolution, conservation and biology:</p> <ul style="list-style-type: none"> Conserve plant biodiversity in the face of global environmental change and mass extinction Provide baseline taxonomic / botanical data as a foundation science Understand the evolutionary processes that have given rise to the world's botanical diversity. <p>Three main cross-cutting themes:</p> <ul style="list-style-type: none"> Scottish bio-diversity Plants and Climate Change Conservation 	<p>The RBGE is a Non-Departmental Public Body (NDPB) supported and sponsored financially by the Scottish Government Rural and Environmental Research and Analysis Directorate (RERAD). RBGE now extends to four sites – Edinburgh, Benmore (Argyll), Logan (Stranraer), Dawyck (near Peebles).</p>
Scottish Agricultural College King's Buildings, West Mains Road, Edinburgh	Prof John Oldham	<p>SAC research programmes are designed to aid the development of the land-based industries, support the sustainability of rural communities, and inform policy makers in the rural sector, both nationally and internationally.</p> <p>Four research groups:</p> <ul style="list-style-type: none"> Land economy and the environment 	Three main campuses at Aberdeen, Ayr and Edinburgh.



EH9 3JG		<ul style="list-style-type: none"> • Animal health • Crop and soils • Sustainable livestock systems 	
Scottish Crop Research Institute Invergowrie Dundee DD2 5DA info@scri.ac.uk	Professor Howard Davies	<p>SCRI's research focuses on processes that regulate the growth of plants and their responses to pests, pathogens and the environment. It includes genetics to breed crops with improved quality and nutritional value as fast as possible.</p> <p>Research is organised into four science programmes:</p> <ul style="list-style-type: none"> • Environment Plant interactions • Genetics • Plant pathology • Plant products and food quality <p>Research is conducted on a wide range of plants, but especially on the crop plants barley, potato, blackcurrant and raspberry.</p> <p>The main customer for the research is the Scottish Government.</p>	SCRI has been advising farmers in Scotland that they are likely to get longer growing seasons as climate change kicks in.
Scottish Agricultural Science Agency Roddinglaw Road Edinburgh EH12 9FJ info@sasa.gsi.gov.uk		<p>Six research themes: genetic modification, pesticides and wildlife, plant health, plant variety testing, seed potatoes, seed testing and certification.</p> <p>Strengths in more depth include:</p> <ul style="list-style-type: none"> • Ensuring the quality of seeds and tubers for planting, and new crop varieties; • Keeping field and horticultural crops free of damaging diseases; • Keeping serious pests of plants out of the UK and Scotland; • Developing new and more sensitive diagnostic tests for pests and diseases; • Preserving and maintaining a wide range of historic, heritage and other varieties of potatoes, cereals, peas and brassicas; • Monitoring the pesticide load in our diet, and the pattern of use of pesticides in Scotland; • Protecting wildlife against deliberate or accidental poisoning • Understanding the ecology of important vertebrate species (e.g. rabbits, foxes, 	

		geese).	
Roslin Institute Roslin Biocentre Midlothian EH25 9PS	Professor Alan Archibald (science contact) Malcolm Bateman (commercialisation contact)	<p>Aim is to understand how genes – individually and collectively - determine the biological characteristics of cells, animals and populations.</p> <p>Key areas are:</p> <ul style="list-style-type: none"> • Numerical genetics – which builds on our expertise in mathematical genetics theory to develop numerical models, methods and approaches. • Farm animal genomics – which develops and applies molecular and information tools to study the relationships between genes and their functions and makes these tools widely available to the research community • Genetics of complex traits – which studies complex biological processes and their genetic control. • Genetics of host response to infectious diseases – which aims to focus on understanding the genetic basis for differences in resistance to diseases. • Operational genetics – which is focussed on making the knowledge gained from genetics appropriate and available to a wide range of stakeholders such as policy makers in government and international bodies such as the UN, as well as a range of different breeding organisations ranging from international companies to local breed societies. • Animal stem cells – which aims to understand the regulation of stem cell self-renewal and differentiation in different animal species. • Genetic modification – which aims to refine and utilise transgenic methodology in farm species. • Developmental systems - which seeks to identify conserved mechanisms underlying growth and differentiation in animals. 	<p>BBSRC institutes are expected to fulfil a role in the UK Science base that is distinct from that of a university department. Roslin Institute makes a major contribution to each of the three main themes in the BBSRC Institutes Science and Innovation Strategy (sustainable agriculture and land use, animal health and welfare and human health and well being).</p>

6. Conclusions

Scotland's Commercialisation and Research Asset Base

Scotland's universities deliver world class research well beyond the volumes expected for a small country. By contrast, research by businesses as a share of the Scottish economy has long lagged behind other developed countries⁹⁴. The gap between universities and businesses raises the question of whether Scotland is making the most of the commercial opportunities from its research asset base.

The scale of higher education research in Scotland is impressive and often cited as a key strength of the economy. Nearly 9,000 staff are actively involved in nearly £600 million of research each year with just over £33 million funded from commercial sources. Further activity arises from government funded research as businesses and universities commercialise research in the form of patents and spinout companies.

Scotland's older (pre-92) universities produced nearly 900 patents from 2002 to 2006, around 150 patents each year. It is likely that the commercial focus and delivery of universities will continue to grow following the recent announcement that 10% of government funding will be on pursuing innovations that support the Scottish Government's economic priorities.

Much of this world class commercial research is undertaken with academic partners from around the world and large international companies. Scotland is a small country and universities often need to work internationally to provide the economies of scale and level of investment needed to exploit commercial research.

Imperial College secured more research funding than all of Scotland's older universities combined. Strategic partnerships in Scotland are common across all research areas ranging from SuperGen in energy to the Scottish Universities Life Sciences Alliance (SULSA) addressing life sciences.

Priority of Research within Priority Industries

This report has pulled together a wealth of commercial success, research with commercial potential and universities already investing heavily in infrastructure to further foster commercialisation. Aside from the issues of commercial research spreading well beyond Scotland, a key theme ran through all of the priority industries as to how much research could reasonably be absorbed by businesses in Scotland.

The Scottish economy is heavily driven by priority industries where the demand or need for research is relatively low. R&D spending by tourism, food and drink and financial services as a share of value added⁹⁵ is low. These industries are arguably driven by innovation rather than driven by research and development.

⁹⁴ see Roper et al, 2006

⁹⁵ Scottish Government: Input-Output Tables and Multipliers for Scotland, 2004, December 2007

For other areas like life sciences, Scotland does not have a significant production base and this is unlikely to change significantly in the near future. Building on its world class reputation and the current liberal research environment, in comparison with countries like the United States, Scotland is likely to remain an attractive location for life sciences investment in R&D facilities.

Energy stands out as an area where university research, commercial activity and job creation could be better aligned in the future. The latest Scottish Government input-output data suggests energy (electricity, oil and gas) accounts for around one fifth (20.7%) of all business R&D in Scotland⁹⁶. Scotland has already witnessed strategic partnerships being formed among universities, including the SuperGen consortium. Scotland has an established base of larger energy companies as well considerable natural resources in oil, gas and renewable energy with the latter being an area likely to see significant growth.

The Fit Between Scottish R&D and Scotland's Priority Industries

It is perhaps surprising that most (91%) of Scotland's universities research grants and contracts income has potential or actual relevance to Scotland's priority industries (national and regional). Some 54% of this research income in Scotland is of relevance to life sciences, while 25% is of relevance to energy. A substantial proportion (20%) of research grants and contracts income was in areas relevant to digital markets and enabling technologies, with a degree of overlap with energy.

Collaboration and relationships between priority industry teams, individual businesses and academia need to reflect this reality and act to strengthen Scotland's capability in departments covering core disciplines such as clinical medicine, biological sciences, physics, electronic engineering, mechanical engineering, mathematics, and chemistry. These are playing lead roles or key support roles (e.g. mathematics) in research pools such as SULSA, SUPERGEN (UK-wide), and ScotCHEM.

Sectors such as chemical sciences are R&D intensive, contribute significantly to the economy, and play an enabling role in building Scotland's capability in energy (biofuels) and life sciences (in respect of therapeutics). Yet, because the sector is of modest scale in absolute terms, its strategic importance for wider economic development is prone to being overlooked.

Life sciences, energy and creative industries all appear well served by Scotland's research base; notwithstanding the desire to further grow our capability in each of these. However, by contrast, a number of Scotland's national priority industries are not at all well represented in terms of research capacity in Scotland's universities.

⁹⁶ Scottish Government: Input-Output Tables and Multipliers for Scotland, 2004, December 2007

In particular, engagement between Scotland's research community and either financial services or tourism is especially weak, with a maximum of £12.8 million and less than £0.1 million, respectively, for sectors that together contribute between them £11.2 billion of Scotland's economy and around 318,000 jobs⁹⁷, with many more jobs supported by these sectors. Food and drink also fared poorly (£8 million in research grants and contracts income), despite providing an estimated 122,000 jobs in Scotland.

New Tricks from Old Universities?

Scotland's pre-92 universities are more research intensive, in general, and account for 84% of all research income in Scotland. However, in terms of income those institutions are also more heavily dependent upon Office of Science and Innovation (OSI) research council and UK charitable sources than are the post-1992 universities. This in part derives from a concentration on biomedical or therapeutic research which may be blue skies, and therefore cutting edge, but perhaps not be as close to commercialisation, while 'ancients' have a considerable footprint in terms of social sciences research that does not have a direct, commercial application.

By contrast, Scotland's new universities are less research intensive, but have developed a greater propensity to attract UK commercial research (18.6%) and EU funding (12.1%), such as Seventh Research Framework Programme (FP7)⁹⁸, as a proportion of total research income. This compares with 6.8% and 6.2%, respectively, for the older (pre-92) universities.

Post-1992 universities are also more reliant upon funding from UK based government, local authority and health trust related funding. This reflects a greater focus upon research that is close to market or which has a commercial application, e.g. medical appliances rather than therapeutics, as well as engineering solutions, or software design.

Theoretically, if pre-1992 universities were able to attract a similar proportion of funding from UK industry or commercial sources alone, then total UK sourced funding of this type in Scotland would have risen from £33.3 million to £64.9 million in 2005/06, i.e. almost double the actual figure, or the equivalent of attracting the research of another medium sized university to Scotland.

Global Research, Local Impacts?

Today, Scotland's top research Universities remain its 'ancients', i.e. Edinburgh, Glasgow, Aberdeen, and St Andrews, or those arising from the civic university era such as Dundee and Strathclyde. This has resulted in a geographic concentration of research activity in historic locations, such as St Andrews, and/or urban areas.

⁹⁷ Including an estimated 108,000 direct financial services jobs and 210,000 employed in tourism.

⁹⁸ http://cordis.europa.eu/fp7/home_en.html

Of the top ten research HEIs in terms of income, six are located in the East of Scotland along with £334 million (58%) of all research income. By contrast, we estimate⁹⁹ that less than £1 million in research is attracted to South of Scotland satellite campuses of University of Glasgow, University of West of Scotland or Heriot-Watt University¹⁰⁰, i.e. less than 0.2% of the total research income across Scotland's HEIs.

In 2006, 63% (or £346 million) of R&D in business¹⁰¹ was located in the East of Scotland, despite it only being home to 36% of employment¹⁰². Less than 1% of business R&D (£4.8 million) was in the South of Scotland, despite 4.5% of employees being based there. Similarly, Highlands and Islands had 8.4% of employment, but just 1.6% of Scotland's HEI research income and, and an estimated 2.6% of business R&D.

An estimated 68% of circa £105 million of funding for Government research institutes, such as Moredun Institute, Roslin Institute, Institute for Animal Health and the Centre for Ecology and Hydrology is also located in the East of Scotland, further boosting this economy. It may be unrealistic to see these weaker regions match spend on R&D in the East of Scotland, even in the long-term, but policy may need to reflect upon such disparities, and seek to promote a degree of convergence, if HEIs and their impacts on economic development are explicitly recognised.

Collaboration between research-led universities, SE and local partners, where appropriate to do so, is important in order to see a ripple out from the East of Scotland and to help raise the game of local economies. Neither Scottish Enterprise, nor the Scottish Government, should attempt to dictate to Universities where the research is located. However, the location of research could be influenced through incentives. While local HE research can act as a driver for inward investment, where this is not feasible or practical, these weaker regional economies could also be strengthened by providing greater encouragement of linkages between local employers and relevant research active HE elsewhere in Scotland.

The Terms of Trade

For those areas of Scotland's research capability that are not directly related to Scotland's national or regional priority industries, the question might arise as to what Scotland actually gains from investing scarce resources in them, if they are unlikely to generate employment locally. There are of course a multitude of drivers for such research, going beyond economic considerations. However, a more subtle point is to assess the rationale for investment in aspects of work relative to priority industries that cannot be exploited in Scotland.

In those circumstances, it is clear that Scotland may benefit in a number of areas, through:

- Generating licensing income from intellectual property rights, and re-investing these in Scotland's research capability, sustaining or growing research jobs.

⁹⁹ No campus breakdown is available for satellite campuses, but as set out in the report, research in the South of Scotland is very modest.

¹⁰⁰ Average for 2007-2009 is circa £300k per annum –see <http://www.hw.ac.uk/sbc/Research/index.html>

¹⁰¹ Scottish Government: *Business Enterprise Research and Development Scotland 2006*, based upon data taken from ONS (IDBR)

¹⁰² Scottish Government: Table 8, *Scottish Corporate Sector Statistics 2007*, taken from ONS (IDBR)

- Reputational benefits, e.g. the creation of the cloned “Dolly the Sheep” has firmly put Scotland on the map, generating perceptions of Scotland as a cutting edge country in the field of biomedicine. In effect, ‘Dolly’ bought Scotland thousands of column inches and minutes of free airtime, all sending a positive message to investors.
- Life Sciences is a global market and diseases do not know boundaries. Patients in Scotland, and rest of UK, will benefit from medical breakthroughs discovered in Scotland but exploited elsewhere.
- Exporting knowledge, especially in areas such that might help address global issues such as climate change, volcanology, food security or viral pandemics, helps to contribute to alleviating problems that threaten us all.
- Investment in R&D can attract match funding from other commercial, governmental or charitable sources and, potentially, attract foreign direct investment from international companies, i.e. manufacturing capacity to exploit research that could be attracted to Scotland, if the wider economic context is also favourable.

However, some of the indicators of the benefits of commercial research will be difficult to measure and extend beyond the mapping presented in this report.

Energy stands out as an area where university research, commercial activity and job creation potential are all well-aligned, due to the presence of an established base of larger energy companies, as well as considerable natural resources in oil, gas and renewable energy. Scotland’s energy-related academic base is well placed to help exploit the twin challenges of a looming global energy crisis and the threat of climate change and is attracting international partners. Scotland can and must ensure that it grasps this opportunity before the technology is exploited elsewhere.

Chemical Sciences is an example of a sector that does present some opportunities to exploit research within Scotland, but, in a similar fashion to Life Sciences, there may also be considerable opportunities for collaborations with international commercial sponsors and future licensing opportunities for manufacturing overseas.