THE CHANGING UK DRUG DISCOVERY LANDSCAPE

For the Association of the
British Pharmaceutical Industry

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For the Association of the British Pharmaceutical Industry
Prepared by TBR's Economic Research Team and CBSL

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CONTENTS

1 SUMMARY

The UK has historically played a leading role in the research and development (R&D) of new medicines. However, the increasing globalisation of the industry, combined with the widely recognised decrease in pharmaceutical R&D productivity, has led to a changing environment in how medicines are discovered and developed globally.

Efforts to reverse trends in productivity have often focussed on drug discovery, specifically looking to improve the identification of candidate medicines with robust safety and efficacy profiles based on a good understanding of disease. This has led to a number of changes for drug discovery, including both scientific and technological advances, and evolving business models and patterns of innovation.

The impact of these changes on the UK environment is poorly understood. The UK life sciences sector overall remains strong, with the biopharmaceutical industry making the largest R&D investment in the UK, over £4 billion in 2013, and employing over 70,000 people. Nonetheless, the closure of several large R&D sites in the UK has led many to hypothesise that drug discovery activity has fallen significantly.

However, there is little publicly available data to support this since it is difficult to isolate discovery activity from broader trends in preclinical and clinical development work. In this report we have used a combination of quantitative surveys and expert interviews to generate a robust evidence base of the shifting drug discovery landscape in the UK.

1.1 Key findings

There has been significant change in the UK's drug discovery landscape in the last decade. Almost all **large biopharmaceutical companies have significantly decreased their employment in in-house discovery in the UK** over this period. Given that these companies account for around 75% of all employment in the sector, the impact of this loss is substantial, running to several hundred jobs.

In contrast, **many small and particularly mid-sized companies have increased UK discovery employment over the same period.**

Additionally, many large companies have actually increased overall investment in discovery activities in the UK, with over 60% increasing outsourcing and collaborative working in the last 10 years. This suggests that the decrease in in-house employment in large companies may not have translated to a decrease in absolute investment across the UK. **A majority of large companies also reported increases in specialist staff based in the UK with roles coordinating drug discovery activities globally,** supporting the idea that the UK maintains a prominent global reach and responsibility for delivery of drug discovery.

This shifting landscape is also reflected in **an increase in employment, investment, and commissioning of Contract Research Organisations (CROs) and academic drug discovery centres.** A significant proportion of these specialist suppliers reported more than a 25% increase in employment, with many others only commencing operations, within the last 10 years. Many also reported an increase in work commissioned from organisations based outside of the UK, particularly in the US and the EU. This suggests that the discovery service sector in the UK is growing, with significant global reach. CROs also tended to report a shift in clients, from large companies, towards small firms and academic centres, supporting the view of a changing environment.

However, more organisations overall, particularly large firms, reported a greater increase in their global discovery investment than that in the UK. This could suggest that whilst areas of the landscape may be thriving, overall the UK may be proportionally losing out globally. Thus the UK needs to consider how it can best maintain its position as a central player in a dynamic global discovery landscape.

This report also shows that open innovation approaches, have become central to drug discovery approaches in the UK. Almost all organisations have increased their collaborative drug discovery work, both in the UK and globally. Companies work in partnership with a broad range of partners and through a range of collaborative models. Alliances with biotech firms, academe, drug discovery centres or catapults, have all increased. Notably, the role of research charities in drug discovery seems to be growing, with no large companies reporting a decrease in collaboration with UK charities.

> "There are three factors that are important for the drug discovery landscape in the UK; world class scientists that understand disease biology and connect drugs to patient outcomes; the environment, particularly having a vibrant biotech sector; and the adoption of innovative medicines by healthcare providers"
>
> **Senior Vice President of Discovery at a pharmaceutical firm**

One to one commercial collaborations remained the most common model, but these were followed by precompetitive collaborations, demonstrating a shift to more complex, multi-party, open collaborations.

Interestingly, the distribution of work varied across discovery activities, highlighting strengths and gaps in the UK offering. For example, **high numbers of companies do not undertake activities such as High Throughput Screening or early safety studies in the UK, suggesting these may be capability gaps.**

In contrast, high levels of collaborative work in target identification are conducted in the UK. This reflects the current strength of the UK academic life sciences sector which was widely acknowledged, particularly in the understanding of disease pathways and clinical presentation. The role of academe as part of the UK drug discovery ecosystem, was seen to be particularly important, not only as collaborative partners, but also in areas where industry was less active, for example in rare or neglected diseases. The importance of ensuring that these centres invested in capability that complements that of industry was highlighted.

1.2 Conclusion

These data reflect a dynamic and changing drug discovery landscape in the UK. Large companies are increasingly moving to a networked model for early drug discovery; combining in-house strengths, with external outsourcing and collaboration. Internal laboratory staff in large companies have decreased, but staff coordinating global activities have increased. There are also trends towards increases in drug discovery employment in specialist service providers, and smaller companies. Overall, however, there are indications that the UK is losing out relative to wider global investment.

Such a changing landscape also raises challenges for the future of UK drug discovery, particularly around the development of the next generation of discovery scientists. Such a shift may make it more difficult to gain the breadth of innovation, disease specific, and leadership expertise available to the previous generation.

The UK must therefore consider how it can build on its current strength in the shifting global drug discovery landscape, to ensure it maintains this position and continues to attract global investment in the coming years.

2 THE RESEARCH STUDY

2.1 Aims and objectives

ABPI commissioned TBR and CBSL to produce an evidence base of the changing landscape in early drug discovery in the UK pharmaceutical industry, and the impact of those changes on the UK scientific landscape, over the last five to ten years.

There is currently little available evidence on how the early drug discovery landscape in the UK has changed over the last decade. Evolving models of early drug discovery, for example increased outsourcing of parts of the discovery process to contract research organisations, academe and other small firms, combined with the closure of a number of large UK pharmaceutical R&D sites, is widely believed to have impacted the early drug discovery landscape in the UK. However, the extent of these changes, their impact for both the UK pharmaceutical sector and broader drug discovery landscape, and any effects on drug discovery activities compared to broader R&D trends is difficult to establish.

This report seeks to answer the following research questions.

Research question 1:

How has the drug discovery landscape in the UK changed in the last 5-10 years?

Research question 2:

How have open innovation initiatives/ public-private partnerships (PPPs) affected the drug discovery landscape in the UK?

2.2 Method and data

The work involved a programme of desk research, interviews with key stakeholders in the discovery sector and surveys of organisations involved with drug discovery in the UK.

2.3 Glossary and reference

Two surveys were delivered to different types of organisations, asking about various aspects of the scale and nature of their drug discovery activity.

The following definitions have been used throughout the survey and report, and a further glossary is provided in section 8.1.

2.3.1 Drug discovery

This research focussed on 'early drug discovery' defined as:

- All activities which are undertaken prior to Investigational New Drug (IND)-enabling studies
- Which take place up to identifying lead candidate(s), and
- Before commencing Good Laboratory Practice (GLP) studies.

2.3.2 Drug discovery organisations and survey

Company types

A survey was conducted of both 'drug discovery initiators' and 'drug discovery service providers'.

'Drug discovery initiators':

- Organisations and companies who instigate drug discovery activity to carry out in-house, to outsource, or in collaboration.

'Drug discovery providers':

- Organisations and companies who work for or with drug discovery initiators on drug discovery, either under contract or in partnership.

Much of the data in this report is displayed by 'organisation size' – based upon the total number of UK employees within each organisation.

In some cases, data is also presented by company type. Companies have been categorised, using database information held by the consultant team, as follows:

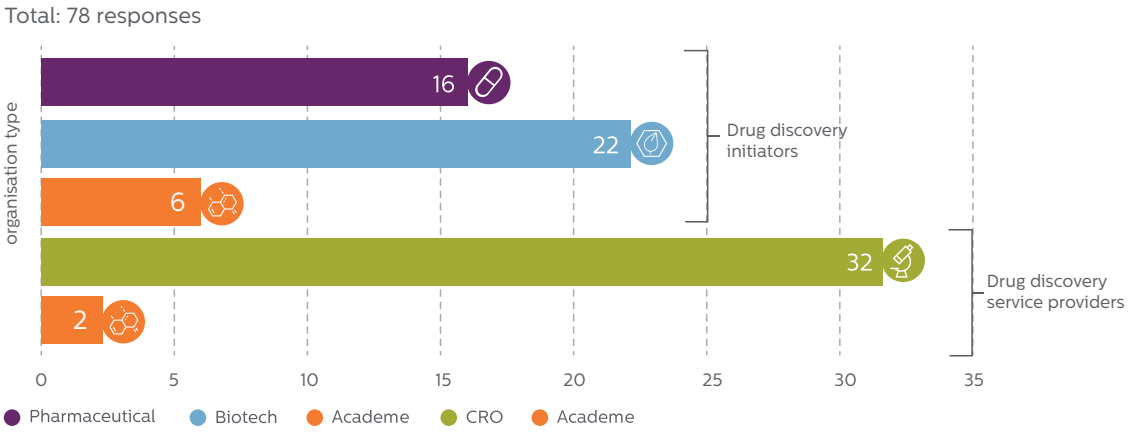
- Contract Research Organisation (CRO): Categorised based on activity and business operation.
- Biotechnology (Biotech) companies: small (under 100 employees) private businesses who specialise in a small number of therapeutic areas
- Pharmaceutical/Biopharmaceutical companies: Large (over 100 employees), usually publicly quoted pharmaceutical companies.

The breakdown of survey respondents who undertake drug discovery activity in the UK is shown in Figure 1.

It should be noted that academic drug discovery centres self-classified as initiators, whereas academic institutions considered themselves as part of the service group.

The study also entailed a literature and evidence review, and interview discussions with key stakeholders across the drug discovery sector.

Figure 1: Breakdown of survey respondents



3 UK PHARMACEUTICAL AND BIOPHARMACEUTICAL INDUSTRY AND DRUG DISCOVERY

The pharmaceutical industry in the UK is one of the key business sectors for innovation, R&D and exports. The industry is part of the life sciences ecosystem comprising academic institutions, specialist service and product suppliers, biotechnology and pharmaceutical companies.

The UK pharmaceutical landscape contains over 600 companies ranging from global corporations to small biotech firms. They are supported by a specialist supplier network comprising 1,300 companies. Together these companies employ 107,000[1] and those involved in drug discovery account for 20% of all UK business R&D investment[2]. The industrial landscape is complemented by a strong biomedical academic sector and clinical capability within the NHS.

There was an estimated 11% decrease in employment within UK large pharma companies between 2006 and 2015 (BIS 2015)

There was an estimated 22% decrease in R&D employment within the pharmaceutical industry over 2005-2013 (ONS)

The pharmaceutical sector is the largest contributor to business R&D in the UK, providing some 20% of investment in 2014 [3,4].

The growth model of the industry is based on the discovery and development of new medicines. However, in recent decades a number of sources have noted a decline in R&D productivity in the industry globally[5].

In response, companies have implemented a range of strategies, including mergers and acquisitions, restructuring, licensing-in products, and increased outsourcing and collaboration (figure i). Many of these strategies impact the whole medicines research and development chain, including discovery activities.

Globally, and in the UK, there has been a downwards trend in employment in large companies. In the UK, a number of companies have closed R&D sites, although other companies have made significant investments.

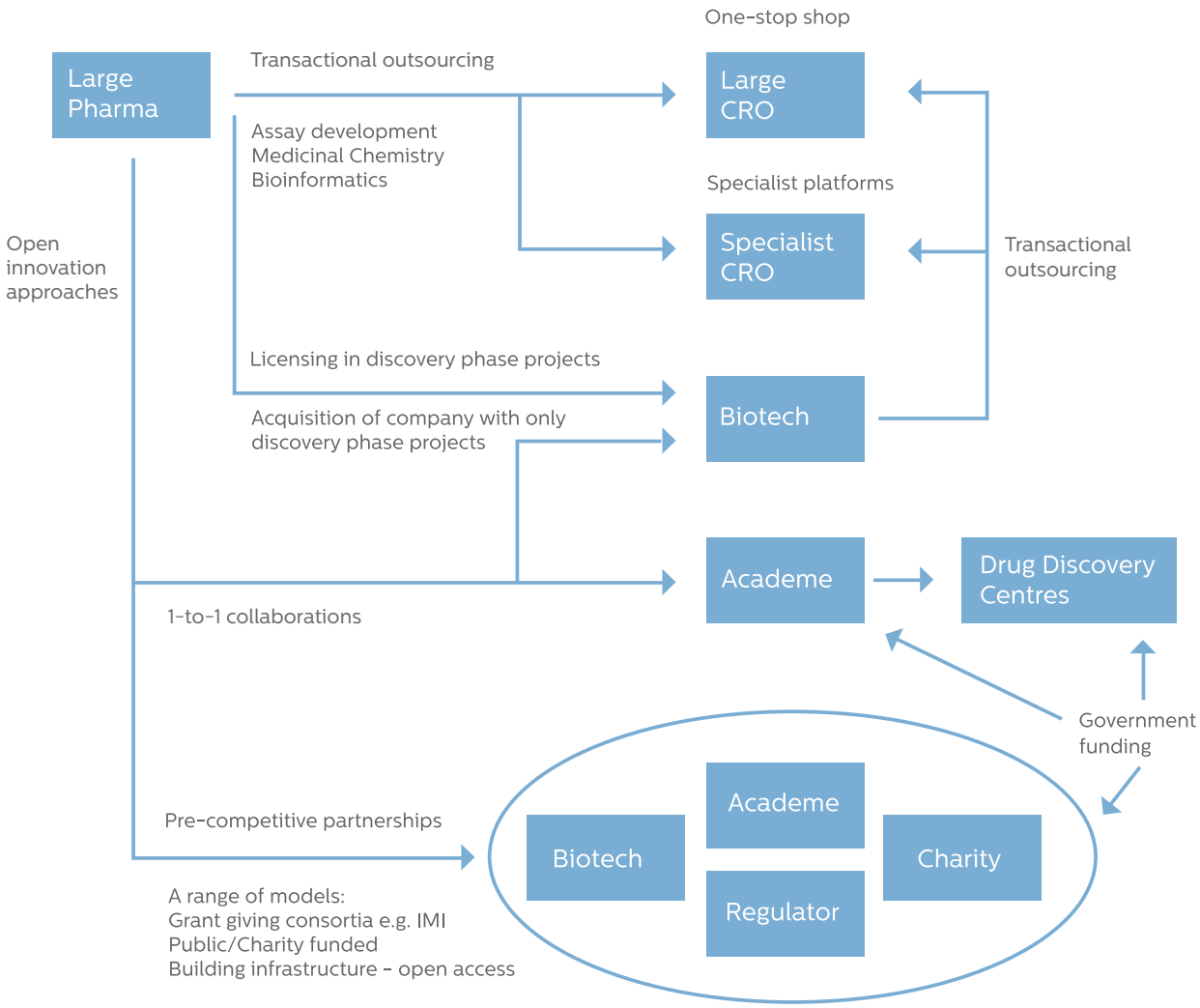
In parallel, the UK has seen a rapid increase in the contract and clinical research sector, which grew employment at a rate of 3.7% per year over 2011-2015[6].

Over the last 10 years, there is also evidence indicating a significant increase in the number of collaborative consortia involving industry, academe and government organisations in the biomedical field. In the area of collaboration between academe and industry, the UK has been at the forefront of this trend. A notable example is the Division of Signal Transduction Therapy (DSTT) at the University of Dundee. Started in 1998 and having attracted over £50m in funding and investment, this centre is believed to be the world's largest single example of direct academic and industry collaboration.

However, it is difficult to separate the impact of these changes on drug discovery specific work from preclinical and clinical development, which accounts for the majority of R&D investment and employment. Similarly, there is little evidence for the impact of these changes on the ecosystem in the UK compared to global changes. This report provides an evidence base for the nature and extent of these changes across the UK early drug discovery landscape in the last 5-10 years.

[1] BIS dataset for 2015 Strength & Opportunity
[2] ONS statistical bullet, released Nov 2015, Business Enterprise R&D 2014.
[3] CBSL analysis of Office of Life Sciences dataset 2015.
[4] ONS Business Enterprise Research and Development, 2012. ONS Annual Business Survey 2012 (provisional), Section C, Manufacturing, Release date 14 November 2013.
[5] Kanna, I. (2012) Drug discovery in pharmaceutical industry: productivity challenges and trends. Drug Discovery Today, Volume 17 (19/20),
[6] CBSL analysis of Office of Life Sciences dataset 2015.

Figure 2: Schematic of the UK early drug discovery landscape, illustrating the broad range of partnerships, models, and strategies employed in the discovery of new medicines.



Source: CBSL 2015

4 DRUG DISCOVERY LANDSCAPE: EMPLOYMENT AND SITES

Key UK drug discovery employment trends

There have been **significant changes** in the drug discovery landscape in the UK over the last decade.

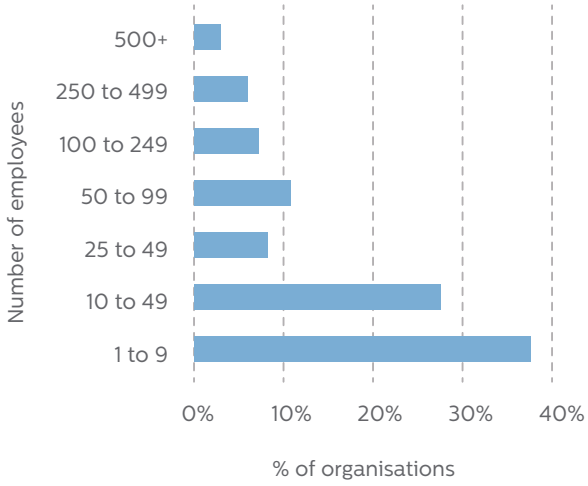
Whilst there has been a **significant reduction** in the number of drug discovery employees within large pharmaceutical companies in the UK over the last five years, many biotech companies, contract research organisations and academic institutions have **increased their staff** working in early discovery.

A significant proportion of specialist suppliers reported more than a 25% increase in employment over the last 10 years, with many others only having begun trading within the last decade.

Pharmaceutical companies employ significant numbers of staff in the UK coordinating global drug discovery. These numbers have **increased** over the last ten years.

Figure 3: Number of UK drug discovery employees in organisations in the UK

n = 69 organisations answered



Source: TBR (Ref: W3/C2/Fig3)

This section presents and discusses the findings from our primary research. We explore changes in the UK drug discovery landscape, focussing on changes in employment within different organisations.

4.1 Overview

From our research sample, the UK drug discovery landscape consists mainly of companies that employ less than 25 people in discovery activities (Figure 3). This is consistent with a recent survey of the UK biopharmaceutical initiator companies that reported 65% employed less than 20 staff and only 10% of companies more than 250[7].

Overall, more UK organisations have reported an increase in the number of employees working on drug discovery in the UK than have reported a decrease (Figure 4), although this varies with organisation size.

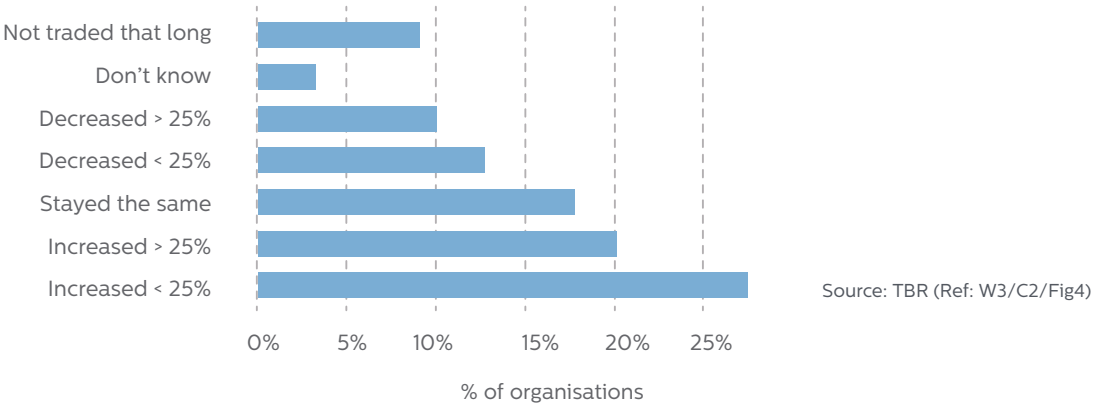
Organisations with the largest number of UK drug discovery employees have seen the biggest falls in the number of staff working in drug discovery, compared to five years ago.

In fact, all organisations with more than 500 drug discovery staff have experienced a fall in these staff numbers compared to five years ago. The same holds true when looking over ten years (Figure 5).

[7] Strength and Opportunity 2015, BIS

Figure 4: Change in UK employees over 5 years at all organisations in the UK

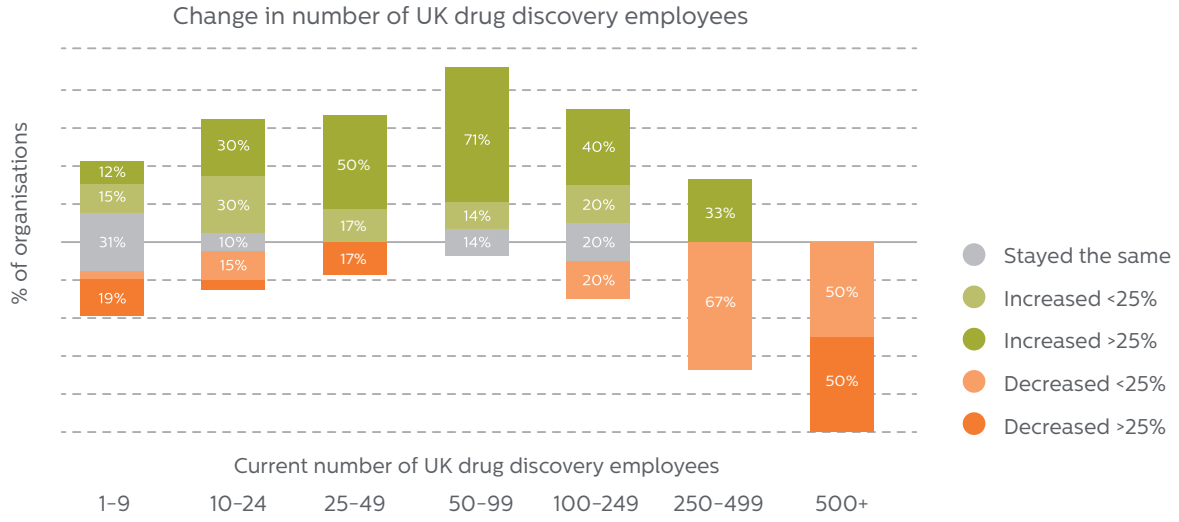
n = 69 organisations answered



Source: TBR (Ref: W3/C2/Fig4)

Figure 5: Drug discovery staff compared to five years ago (by current drug discovery employment)

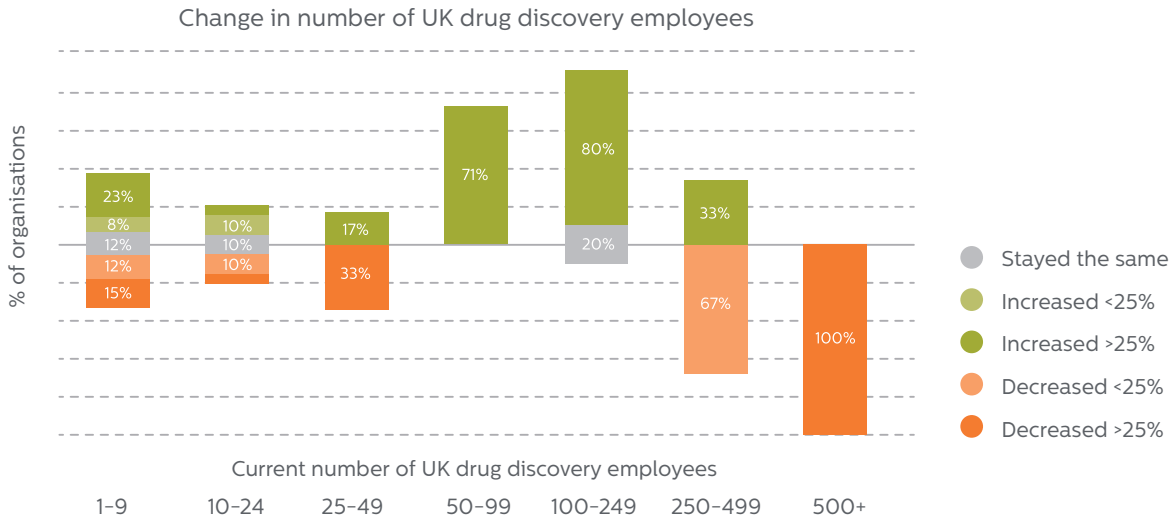
1-9 n = 21 (as % of 26, who have been trading for 5 years and who were able to answer.)
10-24 n = 18 (as % of 20, who have been trading for 5 years and who were able to answer.)
25-49 n = 5 (as % of 5, who have been trading for 5 years and who were able to answer.)
50-99 n = 7 (as % of 7, who have been trading for 5 years and who were able to answer.)
100-249 n = 5 (as % of 5, who have been trading for 5 years and who were able to answer.)
250-499 n = 3 (as % of 3, who have been trading for 5 years and who were able to answer.)
500+ n = 2 (as % of 2, who have been trading for 5 years and who were able to answer.)



Source: TBR (Ref: W3/C3/Fig5) *NOTE: Where columns do not sum to 100%, it is because some firms in these categories were unsure of how employee numbers had changed, or had not traded for 5 years.

Figure 6: Drug discovery staff compared to ten years ago (by current drug discovery employment)

1-9 n = 18 (as % of 26, who have been trading for 10 years and who were able to answer.)
10-24 n = 8 (as % of 20, who have been trading for 10 years and who were able to answer.)
25-49 n = 3 (as % of 5, who have been trading for 10 years and who were able to answer.)
50-99 n =5 (as % of 7, who have been trading for 10 years and who were able to answer.)
100-249 n = 5 (as % of 5, who have been trading for 10 years and who were able to answer.)
250-499 n = 3 (as % of 3, who have been trading for 10 years and who were able to answer.)
500+ n = 2 (as % of 2, who have been trading for 10 years and who were able to answer.)



Source: TBR (Ref: W3/C3/Fig6) *NOTE: Where columns do not sum to 100%, it is because some firms in these categories were unsure of how employee numbers had changed, or had not traded for 10 years.

4.2 Organisation type and size

We see different trends in UK employment across different types and sizes of organisation. Organisation types are defined in section 2.3.

Organisations have been classified based on their total employment in the UK:

- Large: 250 + employees
- Medium: 50 to 249
- Small: 1 to 49 employees

Data from our sample indicates that the majority of large firms who responded have no more than a quarter of their UK employees working in drug discovery (Figure 7).

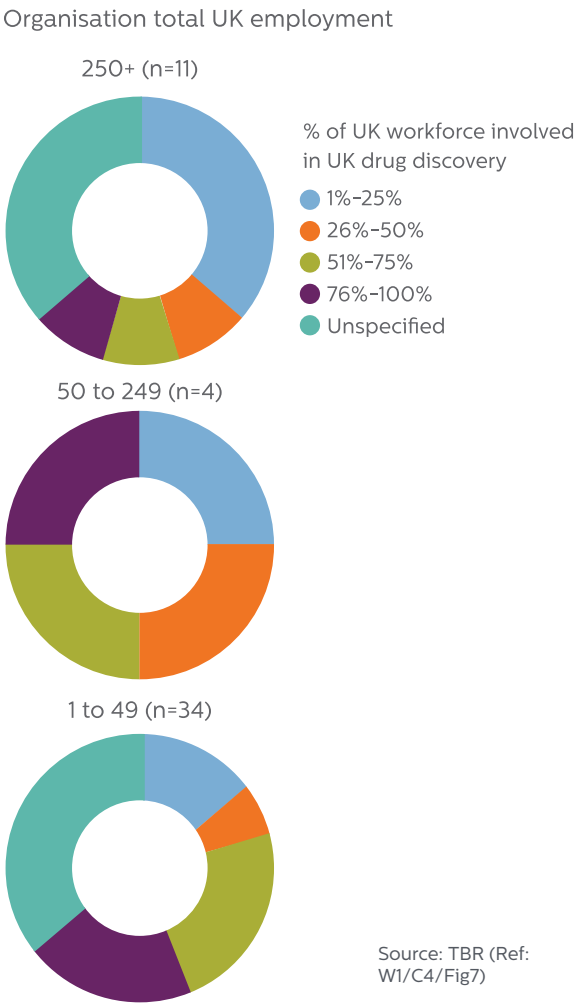
In contrast, the majority of small firms see more than half of their UK employees working in drug discovery.

The majority of large initiator firms have seen falls in the number of staff working in drug discovery in the UK over both five years and ten years (Figure 8 and Figure 9).

Conversely, the majority of medium sized initiator firms have seen an increase in the number of staff working in drug discovery in the UK over both five years and ten years.

Small initiator firms have varied more in changes in drug discovery staff. The majority have seen a rise in the number of staff working in drug discovery in the UK over five years. However, this is in contrast to the ten-year trend which saw more firms losing, rather than gaining, staff with a number of organisations not trading for this duration.

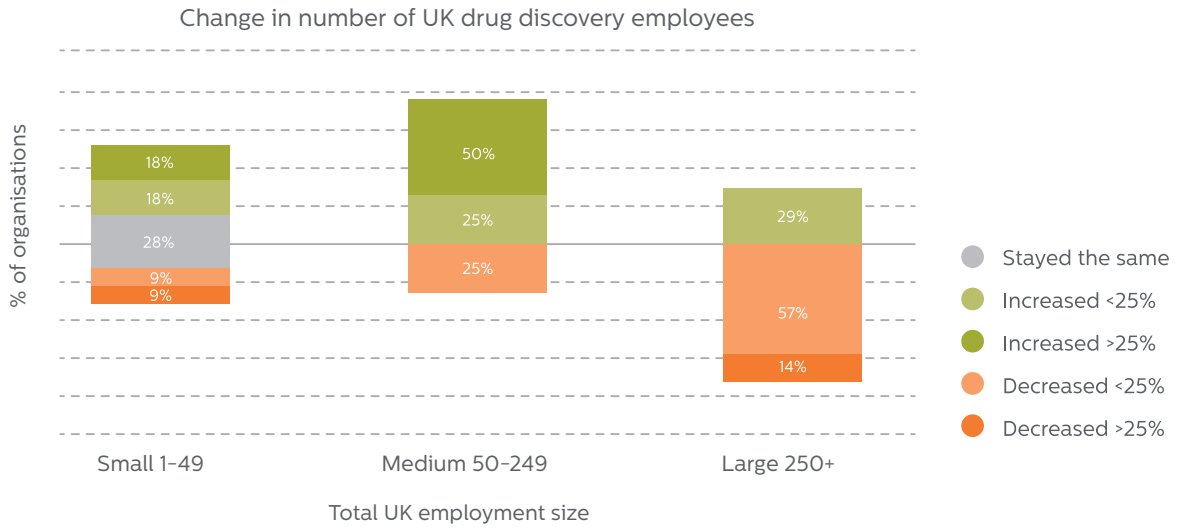
Figure 7: Percentage of total UK employees who work in UK drug discovery by firm size (total employment) (n = 49)



Source: TBR (Ref: W1/C4/Fig7)

Figure 8: Change in UK drug discovery staff compared to five years ago amongst initiators by firm size (total UK employment)

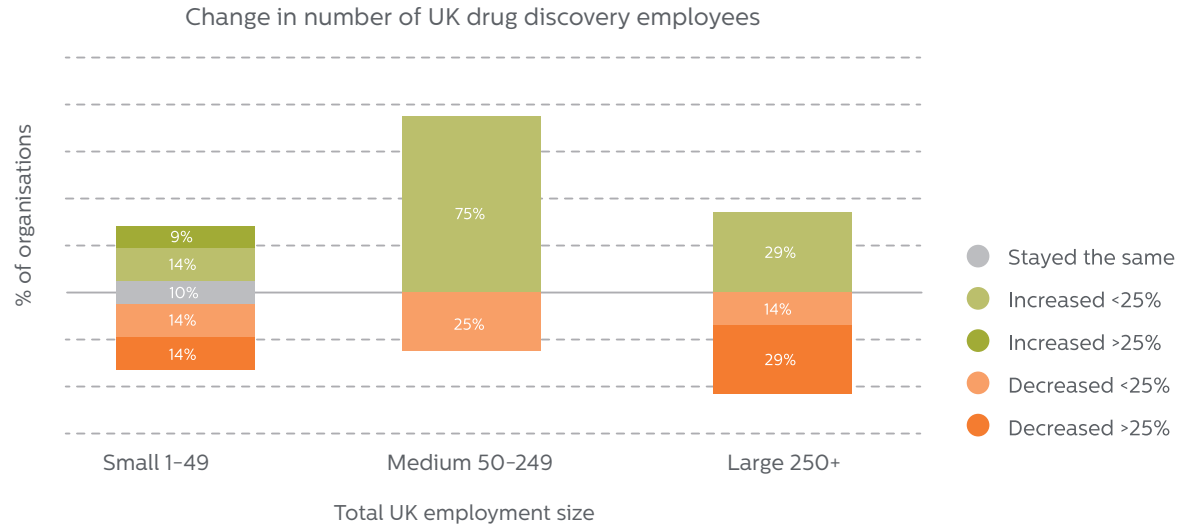
Small n = 19 (as % of 22 who have been trading for 5 years and who were able to answer.)
Medium n = 3 (as % of 4 who have been trading for years and who were able to answer.)
Large n = 7 (as % of 7 who have been trading for 5 years and who were able to answer.)



Source: TBR (Ref: W1/C3/Fig8) *NOTE: Where columns do not sum to 100%, it is because some firms in these categories were unsure of how employee numbers had changed, or had not traded for 5 years.

Figure 9: Change in UK drug discovery staff compared to ten years ago amongst initiators (n = 28) by firm size (total UK employment)

Small n = 13 (as % of 22, who have been trading for 10 years and who were able to answer.)
Medium n = 4 (as % of 4, who have been trading for 10 years and who were able to answer.)
Large n = 5 (as % of 7, who have been trading for 10 years and who were able to answer.)



Source: TBR (Ref: W1/C3/Fig9) *NOTE: Where columns do not sum to 100%, it is because some firms in these categories were unsure of how employee numbers had changed, or had not traded for 10 years.

Interviewees commented on Academic Drug Discovery Centres

"Key part of the UK drug discovery ecosystem."

"Vital in areas where industry was not currently as active, eg in rare or neglected diseases."

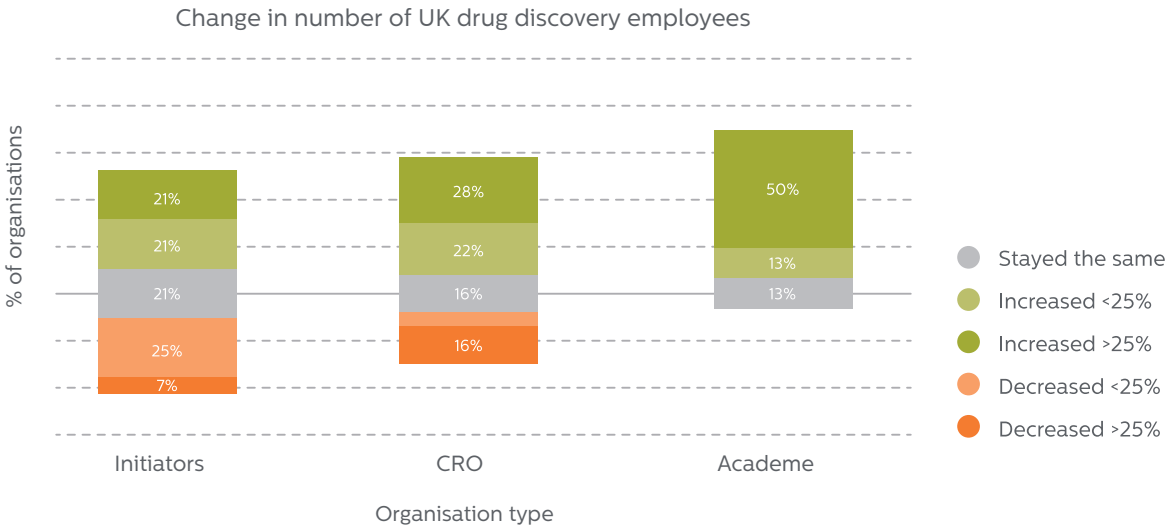
"Important to ensure that centres invest in capability that complements that of industry."

When looking at the data by organisation type, more CROs have seen an increase in the number of drug discovery employees in the UK over the last five and ten years than initiator organisations (Figure 10 and Figure 11). This is consistent with the findings from the interviews where CROs reported strong growth in discovery staff to support projects from a range of academic and biotech clients both in the UK and overseas, and the finding that many CROs and over 60% of academic institutions were not involved in drug discovery ten years ago (Figure 11).

These data supports the views of industry interviewees that the closure of a number of UK R&D sites by large pharmaceutical companies heralded a shift in employment and drug discovery towards CROs, biotech and academe. Interviews suggest that the downsizing of internal activities in large pharmaceutical companies may reflect a desire to focus only on those areas which generate IP directly, with other functions being outsourced or transferred into collaborative arrangements. What is not clear from the data, and merits further investigation, is how this shift may have impacted the relative strength of the UK in certain therapeutic and disease classes, and the impact on skills, experience, and leadership development.

Figure 10: Change in UK drug discovery staff compared to five years ago amongst different organisations

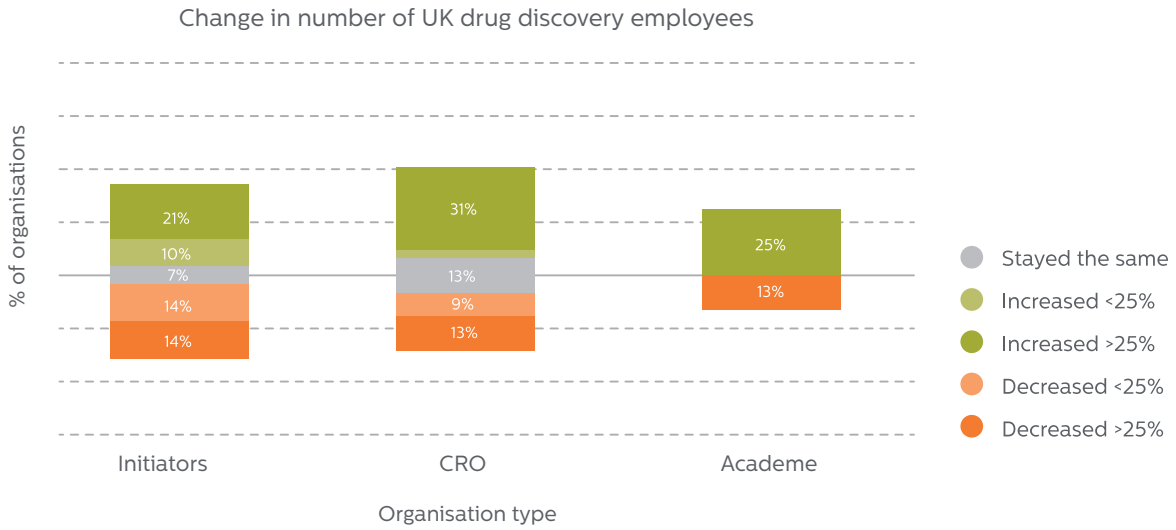
Initiator n = 27 (as % of 29 who have been trading for 5 years and who were able to answer.)
CRO n = 28 (as % of 32 who have been trading for 5 years and who were able to answer.)
Academe n = 6 (as % of 8 who have been trading for 5 years and who were able to answer.)



Source: TBR (Ref: W3/C2/Fig10) *NOTE: Where columns do not sum to 100%, it is because some firms in these categories were unsure of how employee numbers had changed, or had not traded for 5 years.

Figure 11: Change in UK drug discovery staff compared to ten years ago amongst different organisations

Initiator n = 19 (as % of 29 who have been trading for 10 years and who were able to answer.)
CRO n = 22 (as % of 32 who have been trading for 10 years and who were able to answer.)
Academe n = 3 (as % of 8 who have been trading for 10 years and who were able to answer.)



Source: TBR (Ref: W3/C2/Fig11) *NOTE: Where columns do not sum to 100%, it is because some firms in these categories were unsure of how employee numbers had changed, or had not traded for 10 years.

4.3 UK employment in coordinating global drug discovery

In addition to in-house drug discovery staff, pharmaceutical companies also employ significant numbers of staff in the UK who coordinate drug discovery globally. This number has increased compared to ten years ago:

- 63% of pharmaceutical firms (n = 16) have UK staff who manage/coordinate overseas drug discovery.
- This is compared to 36% of biotech firms (n = 22).
- More than half of these pharmaceutical firms (6 out of 10) report that the number of UK staff engaged in this activity has increased compared to ten years ago.

"We have increased significantly our external spend on outsourcing and collaboration in drug discovery and expect this to continue"

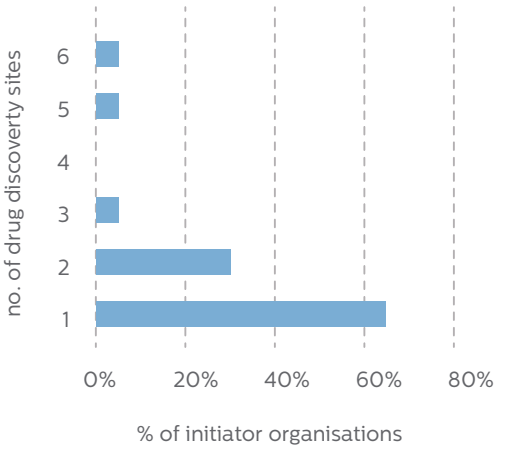
Global Head of External Innovation at a large pharmaceutical company

4.4 Drug discovery initiator sites

In recent years, active drug discovery initiators report that there has been no reduction in the number of UK-based sites used for this activity.

Most drug discovery initiators operate at just one or two sites in the UK (Figure 12).

Figure 12: UK drug discovery sites of initiator organisations (n = 39)



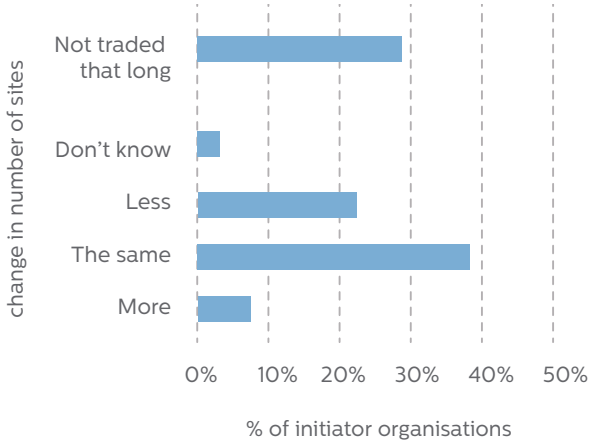
Source: TBR (Ref: W3/C2/Fig12)

Over the ten-year period there has been some change in the number of UK-based sites used for drug discovery, with 20% of initiators reporting a decline (Figure 13).

Interestingly, over a quarter of organisations report they have not been trading for as long as ten years.

This addition of relatively new initiator businesses highlights the dynamic within the drug discovery landscape. The nature and genesis of these firms along with the role they play within the discovery ecosystem calls for further research.

Figure 13: Change in number of UK drug discovery initiator sites from ten years ago (n=39)



Source: TBR (Ref: W3/C2/Fig13)

5 CHANGING LEVELS OF INVESTMENT

Key drug discovery investment trends

Most companies have **increased** their overall drug discovery investment in the UK. However, more companies have **increased** investment globally, which may reflect a proportional decrease in investment in the UK.

There is a mixed picture on in-house discovery investment, both in the UK and globally. Around 1/3 of companies have **increased** in-house investment globally and in the UK. However, more large companies have **decreased** in-house investment in the UK than globally, which may also reflect a proportional decrease in UK-based activity compared to global activity.

In contrast, the large majority of companies have **increased** investment in both outsourcing and collaborative work both in the UK **and** globally.

This section explores changes in the drug discovery investment landscape, drawing upon the survey data.

5.1 Overview of resource investment

Overall, there is a mixed picture for the level of investment in drug discovery in the UK. Across the whole sample of initiator organisations, we see that more have increased overall investment (combining in-house and external investment) in drug discovery overseas than have in the UK. Likewise, the number of organisations reporting a fall in total drug discovery investment in the UK is greater than the number reporting a fall in global investment (Figure 14 and Figure 15).

Therefore, whilst many organisations have increased drug discovery investment in the UK, the UK may be losing out proportionally to other locations.

However, there are striking differences between these trends for pharmaceutical and biotech firms compared with academe and CROs.

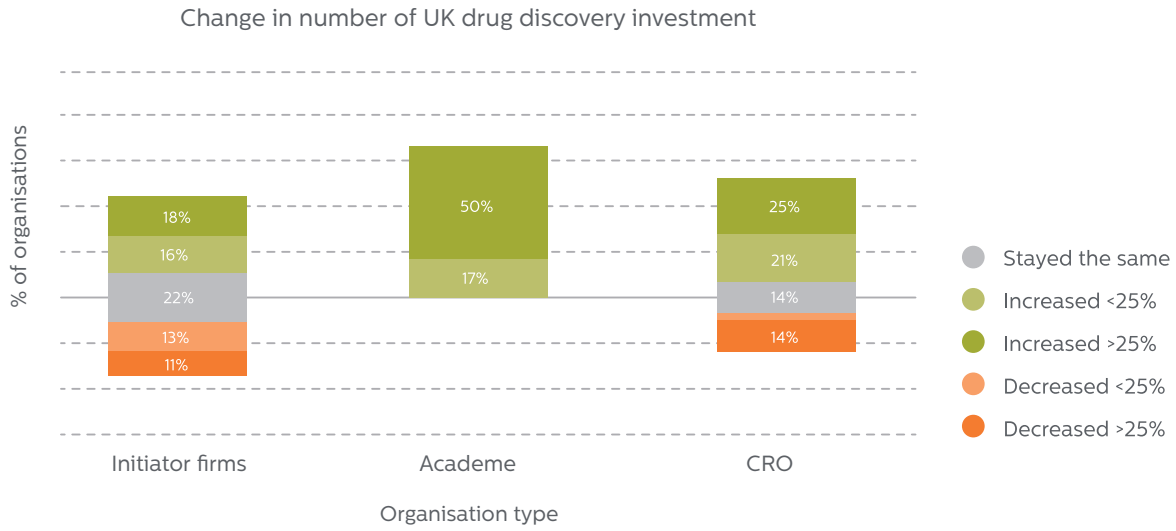
As shown in Figure 14, of the academic respondents who have been working in drug discovery for at least ten years, all of them have seen a growth in investment in the UK.

> "We continue to collaborate with UK academe but our overseas investment has increased to 50% of the total compared to single digit figures 10 years ago. The UK academic sector maintains its traditional strength and attractiveness but other regions and countries are catching up fast"
>
> **Director Academic Liaison at a large pharmaceutical company**

Similarly, on balance, more CROs have increased UK investment than initiator firms (Figure 14).

Figure 14: Change in total UK investment in drug discovery in last ten years by different organisations in the UK

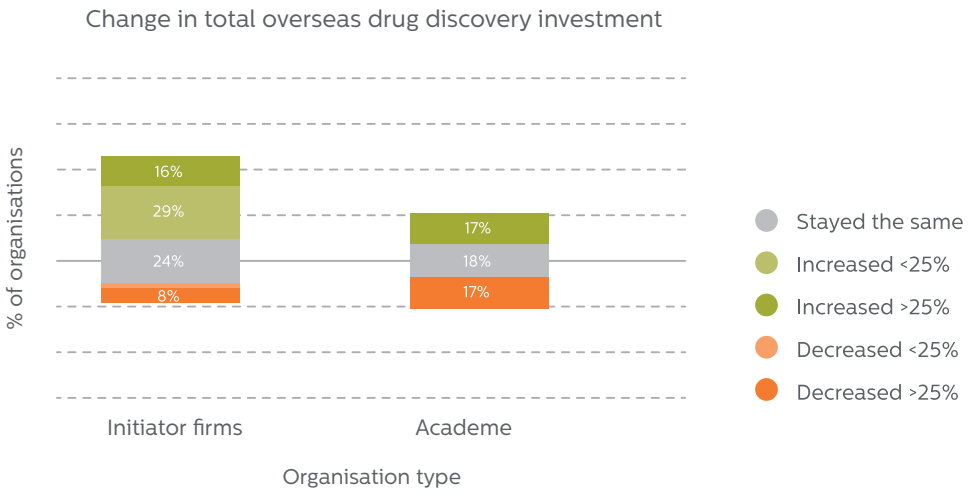
Initiator n = 30 (as % of 38 who have been trading for 5 years and who were able to answer.)
CRO n = 22 (as % of 28 who have been trading for 5 years and who were able to answer.)
Academe n = 4 (as % of 8 who have been trading for 5 years and who were able to answer.)



Source: TBR (Ref: W3/C2/Fig14) *NOTE: Where columns do not sum to 100%, it is because some firms in these categories were unsure of how employee numbers had changed, or had not traded for 10 years.

Figure 15: Change in total overseas investment in drug discovery in last ten years by UK initiator organisations*

Initiators n = 30 (as % of 38 who have been trading for 10 years and who were able to answer.)
Academe n = 3 (as % of 6 who have been trading for 10 years and who were able to answer.)



TBR (Ref: W3/C2/Fig15) *NOTE: Where columns do not sum to 100%, it is because some firms in these categories were unsure of how employee numbers had changed, or had not traded for 10 years.

*Note: CROs were not asked about their global outward investment. Only those firms and organisations who responded to the initiator survey (Survey A) were asked this.

5.2 In-house investment

The picture on investment for in-house discovery is mixed, and varies across organisations (Figure 16 and Figure 17). Over a third of firms say that investment in in-house drug discovery activity has increased over the last ten years, both in the UK and globally.

However, around a quarter report a decrease in UK in-house investment.

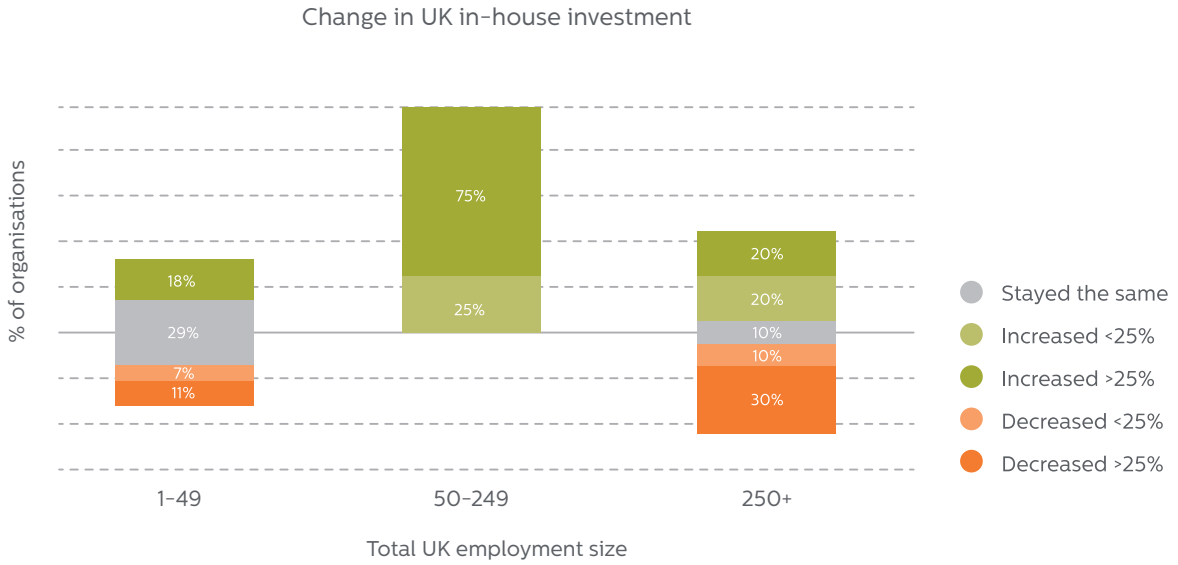
When divide by size, more firms have increased in global in-house investment than have increased UK-based in-house investment (Figure 16) In our sample, all medium sized initiators have increased their in-house UK-based investment compared to ten years ago (Figure 16).

The majority of small firms report either that investment has not changed or that they were not trading ten years ago.

> "I am concerned that there is an erosion of UK drug discovery skills compounded by reduced attractiveness as a career for new graduates"
>
> **Director of Discovery Services - CRO**

Figure 16: Change in UK in-house drug discovery investment by initiator organisations compared to ten years ago, by firm size (total UK employment)

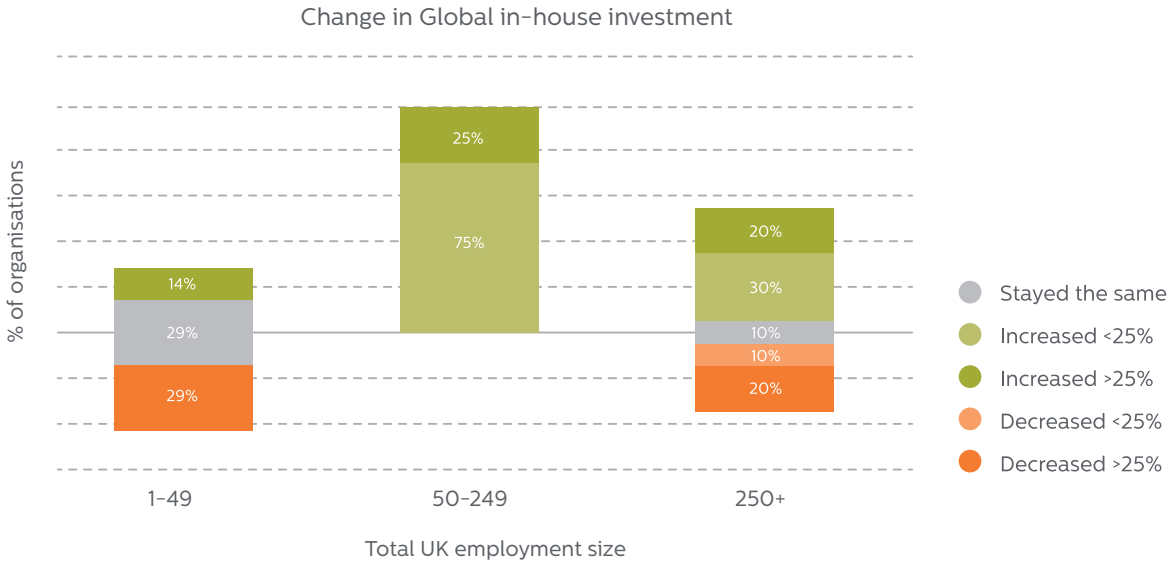
Small n = 20 (as % of 28 who have been trading for 10 years and who were able to answer.)
Medium n = 4 (as % of 4 who have been trading for 10 years and who were able to answer.)
Large n = 9 (as % of 10) who have been trading for 10 years and who were able to answer.)



Source: TBR (Ref: W1/C1/Fig16) *NOTE: Where columns do not sum to 100%, it is because some firms in these categories were unsure of how employee numbers had changed, or had not traded for 10 years.

Figure 17: Global in-house investment in drug discovery by UK initiator organisations compared to ten years ago, by firm size (total UK employment)

Small n = 14 (as % of 28 who have been trading globally for 10 years and who were able to answer.)
Medium n = 4 (as % of 4 who have been trading globally for 10 years and who were able to answer.)
Large n = 9 (as % of 10 who have been trading globally for 10 years and who were able to answer.)



Source: TBR (Ref: W1/C1/Fig17) *NOTE: Where columns do not sum to 100%, it is because some firms in these categories were unsure of how employee numbers had changed, or had not traded for 10 years.

5.3 Outsourcing investment

Very few companies report a reduction in either UK-based or global outsourcing.

Over half of companies say that investment in UK-based outsourcing of drug discovery activity has increased over the last ten years (Figure 18). However, fewer firms (Figure 19) said the same about global outsourcing investment.

This may suggest a proportional increase in UK outsourcing investment compared to global outsourcing investment.

However, this relative increase in UK outsourcing investment appears to be driven mainly by smaller sized firms, so direct comparison of absolute investment levels between the UK and global markets is difficult to infer. These findings are consistent with interviews with CROs that reported a shift in their client base from large pharmaceutical companies to biotech and academe over the last five years. While small and medium firms have tended to increase, or maintain, investment in outsourcing, both UK-based and globally, 25% of small organisations do not outsource any drug discovery overseas.

In contrast, more large firms report that their investment in global outsourcing has increased than for UK-based outsourcing.

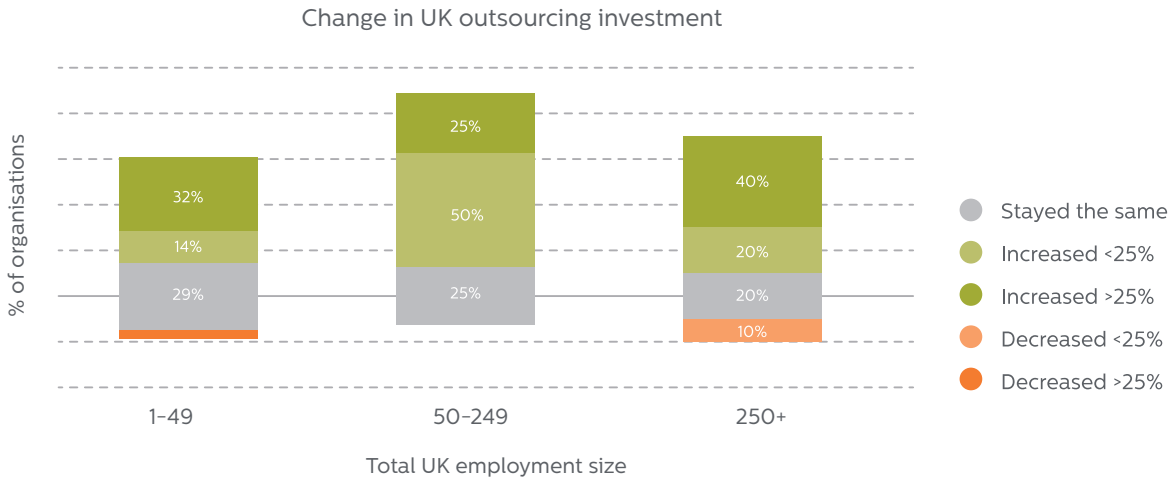
Interestingly, amongst large firms in our sample, there appears to be a relationship between changes in UK-based in-house investment and investment in outsourcing.

Of the four large firms who have decreased UK-based in-house investment, three have increased investment in UK-based outsourcing, and three their investment in overseas outsourcing.

From our interview data, the models and objectives of outsourcing also appear to be dynamic and evolving. A number of large pharmaceutical companies have adopted a model of in-sourcing staff from CROs and these staff on their R&D sites. A number of interviewees suggested that the objective for this model was to increase productivity and investment flexibility. These external staff can represent a significant proportion of the total discovery staff on site. This in-sourcing model not only provides additional resource but also access to specialist knowledge and innovative technology.

Figure 18: Investment in UK outsourced drug discovery by initiator organisations compared to ten years ago, by firm size (total UK employment)

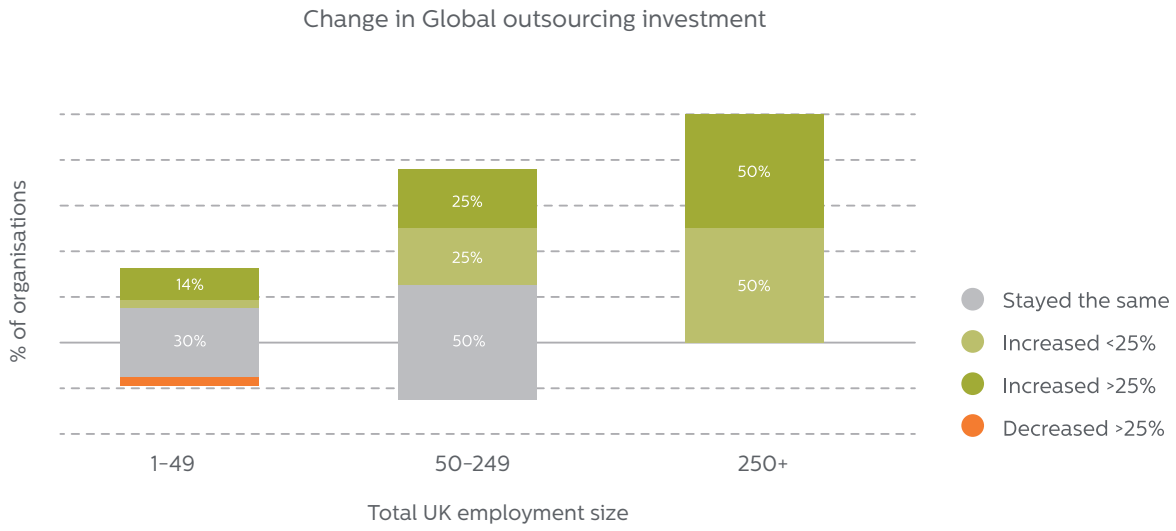
Small n = 22 (as % of 28 who have been trading for 10 years and who were able to answer.)
Medium n = 4 (as % of 4 who have been trading for 10 years and who were able to answer.)
Large n = 9 (as % of 10 who have been trading for 10 years and who were able to answer.)



Source: TBR (Ref: W1/C1/Fig18) *NOTE: Where columns do not sum to 100%, it is because some firms in these categories were unsure of how employee numbers had changed, or had not traded for 10 years.

Figure 19: Investment in Global outsourced drug discovery by initiator organisations compared to ten years ago, by firm size (total UK employment)

Small n = 15 (as % of 28 who have been trading globally for 10 years and who were able to answer.)
Medium n = 4 (as % of 4 who have been trading globally for 10 years and who were able to answer.)
Large n = 9 (as % of 10 who have been trading globally for 10 years and who were able to answer.)



Source: TBR (Ref: W1/C1/Fig19) *NOTE: Where columns do not sum to 100%, it is because some firms in these categories were unsure of how employee numbers had changed, or had not traded for 10 years.

5.4 Collaboration investment

The large majority of responding initiator companies invest more in collaborative drug discovery now compared to ten years ago. This applies both globally and in the UK. The numbers for the UK are greater than those for global collaborations, again particularly for smaller companies (Figure 20 and Figure 21).

In our sample, all large firms (n = 8) who have been involved in drug discovery collaboration globally for ten years or more have increased their investment in this activity. Medium and small sized organisations in our study have been more likely to increase investment in UK-based collaborations than global collaborations.

> "We opened up our external open innovation activities to cover global partners"
>
> **Director Discovery Sciences - large pharmaceutical company**

Although the absolute numbers are small, three times as many have decreased investment in UK collaboration (10%) than have decreased global collaboration investment (3%)

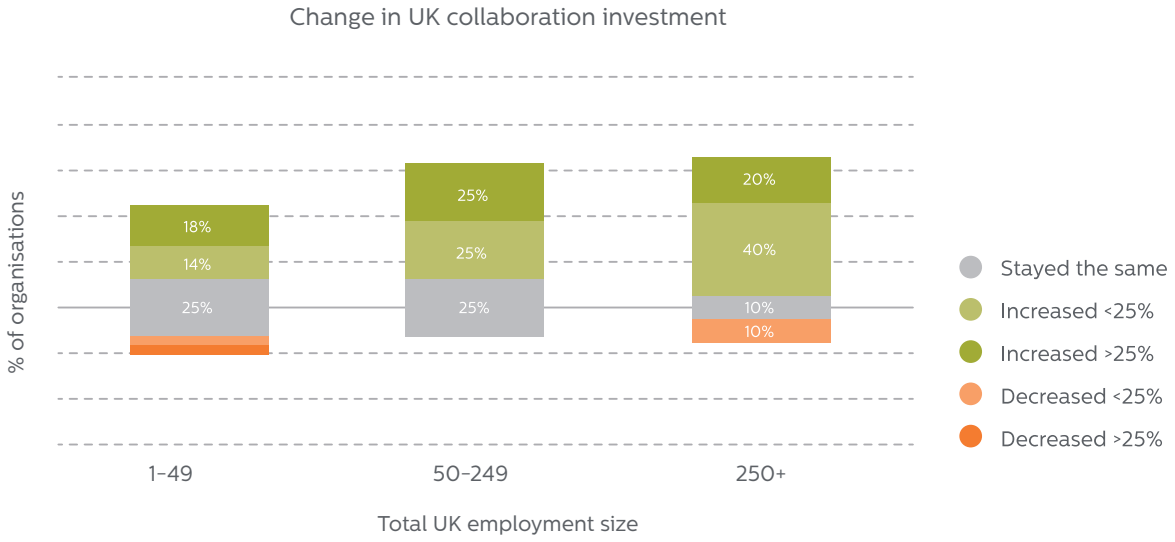
UK Pharmaceutical drug discovery investment – a relationship between in-house and collaborative spend?

The data collected on investment in UK based collaboration suggests a relationship with levels of UK-based in-house investment;

- The four large firms who have decreased UK in-house investment have increased investment in UK collaboration.
- Of the four large firms who have increased UK in-house investment, only two have increased investment in UK collaboration.

Figure 20: Investment in UK-based collaborative drug discovery by initiator organisations compared to ten years ago by organisation size (total UK employment)

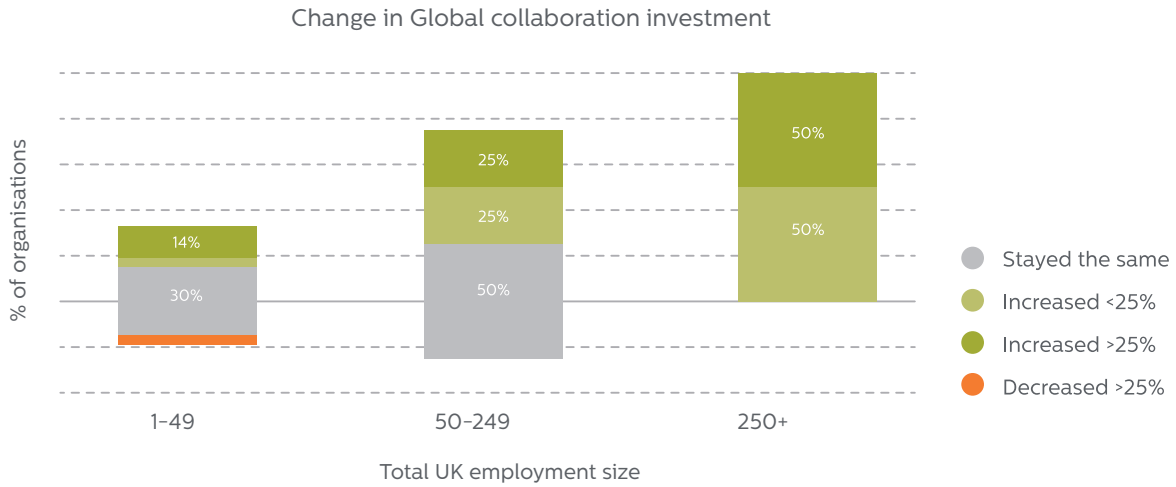
Small n = 18 (as % of 28 who have been trading for 10 years and who were able to answer.)
Medium n = 3 (as % of 4 who have been trading for 10 years and who were able to answer.)
Large n = 8 (as % of 10 who have been trading for 10 years and who were able to answer.)



Source: TBR (Ref: W1/C1/Fig20) *NOTE: Where columns do not sum to 100%, it is because some firms in these categories were unsure of how employee numbers had changed, or had not traded for 10 years.

Figure 21: Investment in global-based collaborative drug discovery by initiator organisations compared to ten years ago by organisation size (total UK employment)

Small n = 14 (as % of 28 who have been trading globally for 10 years and who were able to answer.)
Medium n = 4 (as % of 4 who have been trading globally for 10 years and who were able to answer.)
Large n = 8 (as % of 10 who have been trading globally for 10 years and who were able to answer.)



Source: TBR (Ref: W1/C1/Fig2) *NOTE: Where columns do not sum to 100%, it is because some firms in these categories were unsure of how employee numbers had changed, or had not traded for 10 years.

6 PARTNERSHIP AND COLLABORATION

Key drug discovery partnership and collaboration trends

Pharmaceutical companies **work collaboratively on drug discovery** with a broad range of partners in the UK, including academe, biotech firms, CROs, and charities.

Most companies have **increased their collaboration** with these partners in the UK in the last 5-10 years, particularly with biotech firms, academia, and charities.

The most common types of partnerships are **one-to-one commercial collaborations,** either with other companies or with academe/not for profit organisations.

Licensing deals at the discovery stage with UK licensors have **increased**, particularly from UK based biotech companies.

Looking **at a discipline level,** there are a number of areas of drug discovery work where UK organisations are globally competitive, but some activities which organisations largely conduct outside of the UK, such as High Throughput Screening.

Target Identification and Validation are the more common activities undertaken collaboratively. However, for the majority of drug discovery disciplines (e.g. medicinal chemistry, non-GLP safety and toxicity) outsourcing is more prevalent than collaboration. UK CROs have seen a **significant increase in commissioned drug discovery work** in the last 5-10 years, with as many customers in Europe and North America as in the UK.

This section reports on the survey results relating to collaboration in early drug discovery. Evidence from the literature review and interviews with industry reveal that collaboration is seen as an increasingly important mechanism for addressing the R&D productivity challenge.

While collaboration is not new, the mechanisms for doing so appear to be evolving from one-to-one interactions such as one academic group to one pharma, to more complex interactions involving many players, often involving open innovation approaches.

6.1 Overview of collaboration

A large majority of organisations work in partnership and collaboration when undertaking drug discovery activity in the UK. Most work with more than one type of organisation.

The extent of partnership working varies by the size of initiator organisations (Figure 22).

Publicly funded drug discovery in the UK

Publicly funded investments by organisations including the BBSRC, MRC and Wellcome Trust, has resulted in a network of drug discovery centres. The research shows that there are 24 such ventures in the UK employing over 500 staff with the capacity to carry out over 350 screening projects per year.

Other funding programmes

Interviews highlighted the importance of programmes such as the Wellcome Seeding Drug Discovery initiative and the Biomedical Catalyst for funding early discovery at stages in academe and biotechnology companies before assets attract significant private finance.

Small organisations in our sample collaborate most with CROs and academe.

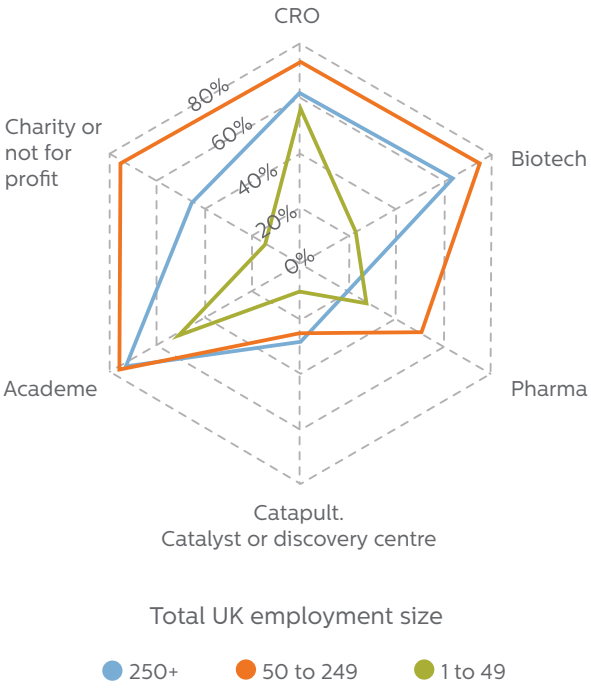
Meanwhile, large organisations most frequently form partnerships with academe, biotech firms, and CROs.

A quarter of medium and large companies surveyed have collaborated with catapults, catalysts or discovery centres (Figure 22).

"Academic drug discovery has the ability to operate in riskier areas of technology and in rare diseases that complements the activities of industry"

Head of Academic Drug Discovery Centre

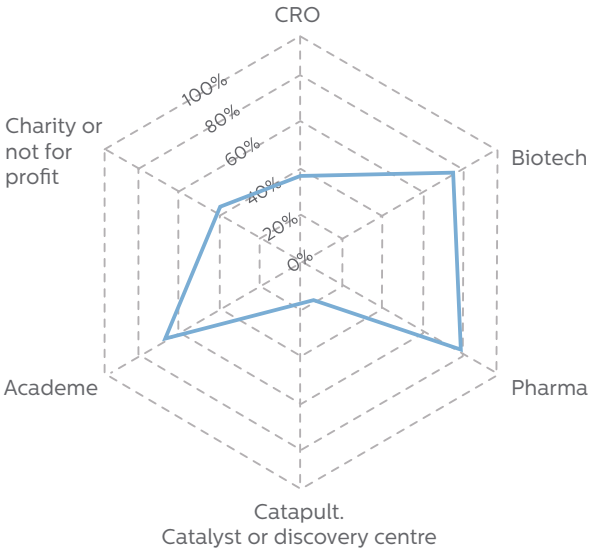
Figure 22: Partnerships made by initiator organisations, by size of organisation (total employment) (n = 48)



Source: TBR (Ref: W1/C2/Fig22)

Figure 23 looks at who CROs collaborate with. This shows that CROs most frequently collaborate with biotech and pharmaceutical firms.

Figure 23: Partnerships made by CRO (n = 32)



Source: TBR (Ref: W1/C1/Fig23)

Organisations reported working collaboratively through a broad range of models (Figure 24). Indeed, interviewees stressed the range of approaches taken by pharmaceutical companies to improve discovery productivity. One to one commercial collaborations were the most common, but over a quarter of all organisations also reported participating in precompetitive collaborations, reflecting increases in complex, multi-party, open collaborations.

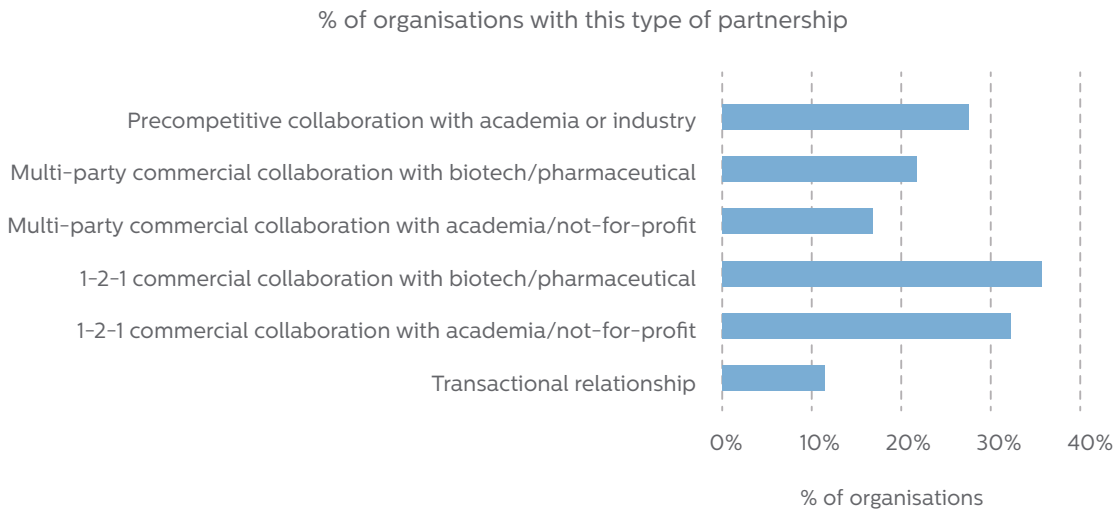
"The UK academic base is seen as world class and in our capability to understand the biology. This was attracting companies to invest in collaborations"

Director, Translational Research, University

It is clear from the interviews and information in the literature, that collaboration within early drug discovery is increasing and has evolved from companies looking to access greater chemical diversity to multi-party, pre-competitive consortia. There are a number of examples of UK instigated public-private consortium that have been established in the last five to ten years.

A number of them such as the Structural Genomics Consortium (SGC) are now global activities linking academic institutions and companies in an open innovation approach. The principles of operation of the SGC and other similar programmes, such as the Centre for Therapeutic Target Validation, are to share data openly with academe and companies, even to those not originally involved in the consortium. Such open approaches of data sharing recognise that with the exponential increase in "omic-data" no one organisation is equipped to successfully interpret and translate the data into new targets and innovative therapies.

Figure 24: Type of partnerships made by all UK organisations (n = 77)



Source: TBR (Ref: W1/C1/Fig24)

6.1.1 Discovery activities by discipline

Most initiator organisations undertake the majority of their drug discovery activities in-house in the UK to some extent (Figure 25).

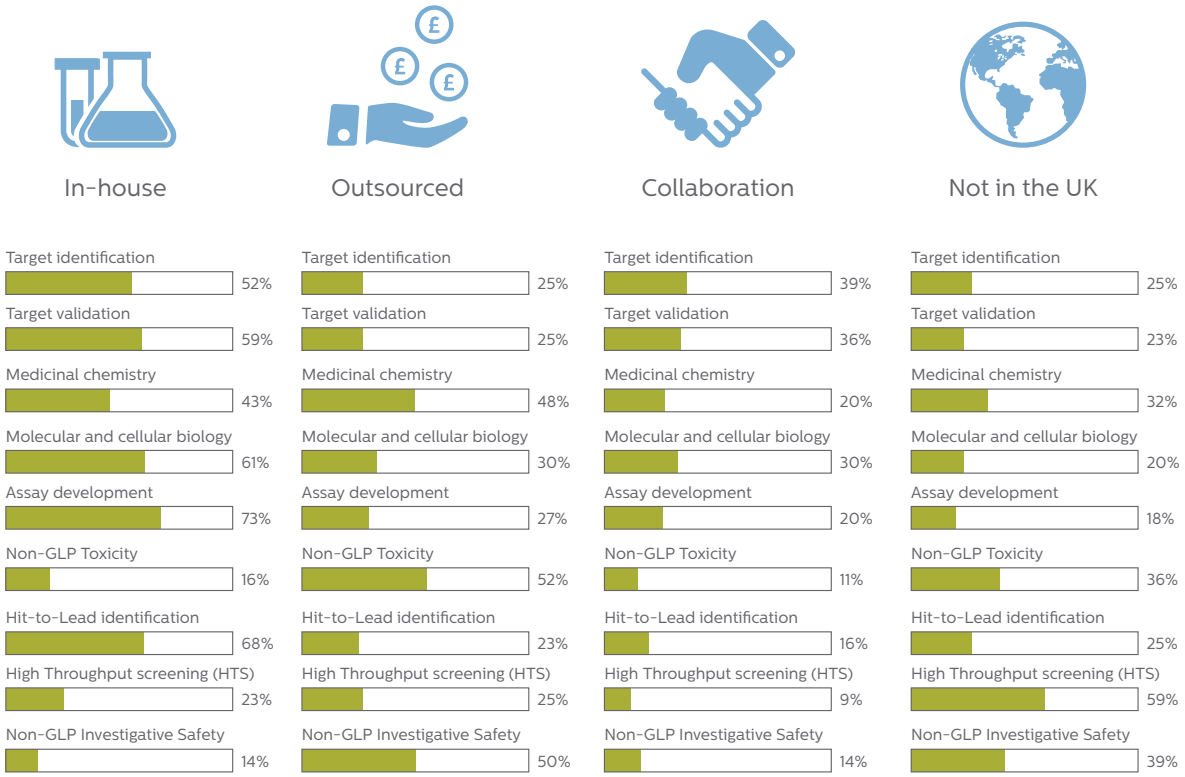
The activities which are most commonly undertaken in-house in the UK are molecular and cellular biology, assay development and Hit-to-Lead identification.

Non-GLP Toxicity and Non-GLP Investigative Safety/Toxicology are the activities most commonly outsourced in the UK, whereas target identification is most often undertaken in collaboration, reflecting many interviewees' comments on UK academe's strong understanding of biology.

Some types of activity are rarely undertaken in the UK. For example, the majority of companies do not conduct High Throughput Screening in the UK. As noted above, UK academic drug discovery centres have capacity for a large number of screening projects and it would be interesting to explore how this capacity is currently used.

The relative movement of such activities outside of the UK is likely to impact the skills base and hence future activities.

Figure 25: Where and how initiator organisations undertake drug discovery: percentage of initiators organisations who work in this field (n= 44)



% of all initiator organisations reporting they undertake this activity, and where this is done (n=44)

Source: TBR (Ref: W3/S6 and Piktochart)

Looking at service provider organisations activities, the most commonly conducted areas are; assay development, molecular and cellular biology, and Hit-to-Lead identification.

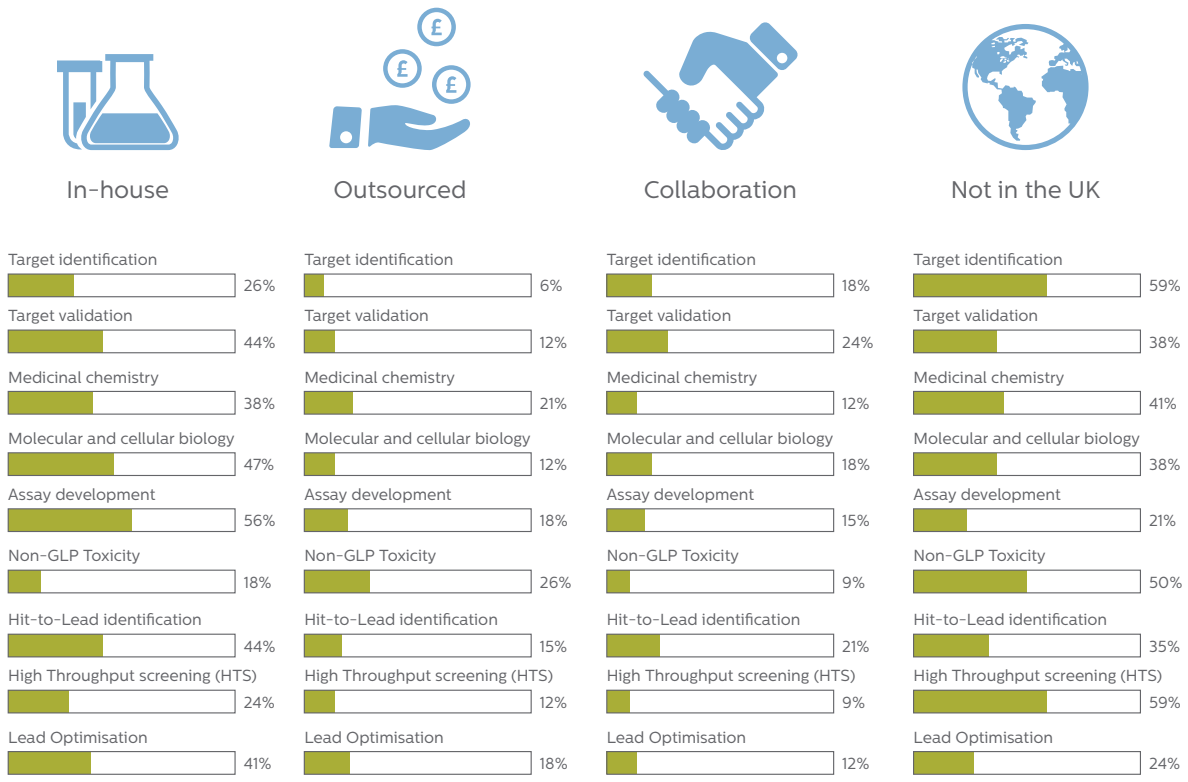
This is interesting as it does not exactly mirror the areas most commonly outsourced in the UK by initiators. This may indicate that many of these activities are undertaken by UK service providers on behalf of global clients.

The next subsection explores the nature of CRO collaboration in more detail, and looks at the global spread of their customers.

As expected there is a much smaller proportion of drug discovery activity outsourced or undertaken in collaboration by service providers (Figure 26).

For several drug discovery activities, service providers say they do not undertake this in the UK, meaning they either do not work in these areas at all, or only do so overseas.

Figure 26: Where and how service providers undertake drug discovery: percentage of service providers who work in this field (n= 34)



% of all service provider organisations reporting they undertake this activity, and where this is done (n=44)

Source: TBR (Ref: W3/S6 and Piktochart)

6.1.2 Contract Research Organisations

A large majority of CROs surveyed report being engaged by pharmaceutical and biotech firms, and academic institutions.

Very few CROs are engaged by catapults, catalysts or academic drug discovery centres.

Interestingly, a third of CROs are engaged by other CROs.

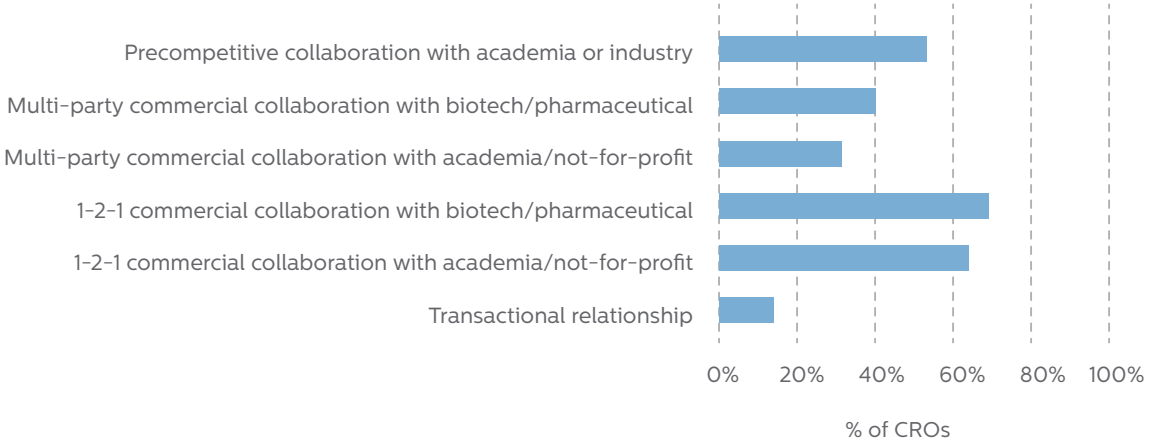
Figure 27 demonstrates that CROs are primarily involved in commercial activities, along with some precompetitive collaboration with academe and industry.

In our sample, UK based CROs are commissioned by as many European and North American based customers, as they are UK- based ones. Interestingly fewer UK CROs work with Asian-based customers (Figure 28).

"We have significantly, over the last 5 years, been adding biology capability particularly, with our client base shifting to academe and biotech firms away from large pharma"

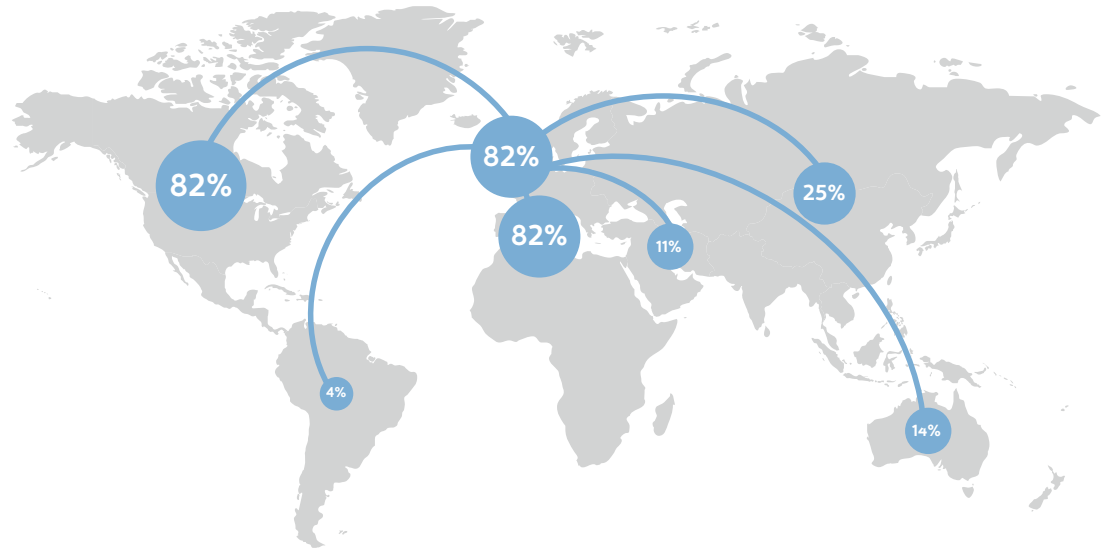
Director Discovery - UK-based CRO

Figure 27: Percentage of CROs engaged in different types of collaboration (n = 28)



Source: TBR (Ref: W2/C1/Fig27)

Figure 28: Percentage of CROs stating they work for customers in different parts of the world (n = 28).

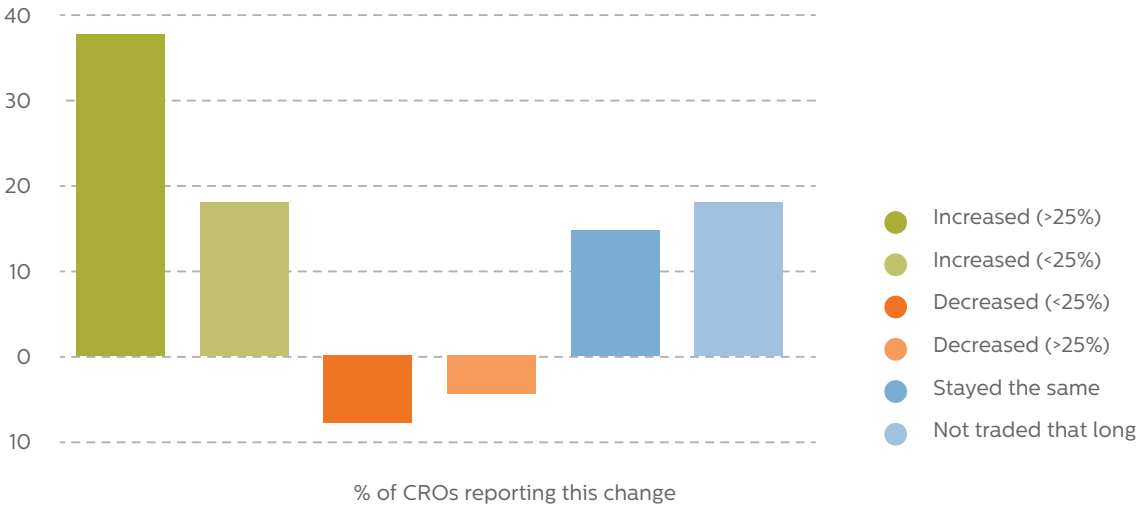


Source: TBR (Ref: W2/C1 and Piktochart)

The large majority of CROs have seen their levels of drug discovery activity in the UK commissioned by other organisations increase in the last 10 years (Figure 29).

Very few have seen commissioned activity fall. In fact, more CROs report that they were not active ten years ago (i.e. have started-up since) than report a fall in commissions, confirming the view that the use of CROs for discovery work has increased

Figure 29: Percentage of CROs reporting change in commissioned activity over five years (n = 28)



Source: TBR (Ref: W2/C1 and Piktochart)

6.2 Changes in partnership investment flows in the UK from large firms

Focussing on the sample of large firms, it is possible to compare the type of collaborations they make, with the way that their collaboration investment has changed.

As shown in Figure 30, the majority of large organisations who collaborate or partner with academe, along with biotech firms and CROs have increased their investment.

We see that for all types of partnerships, apart from ones with other pharmaceutical companies, more large firms have increased their investment in the UK over ten years than have decreased it.

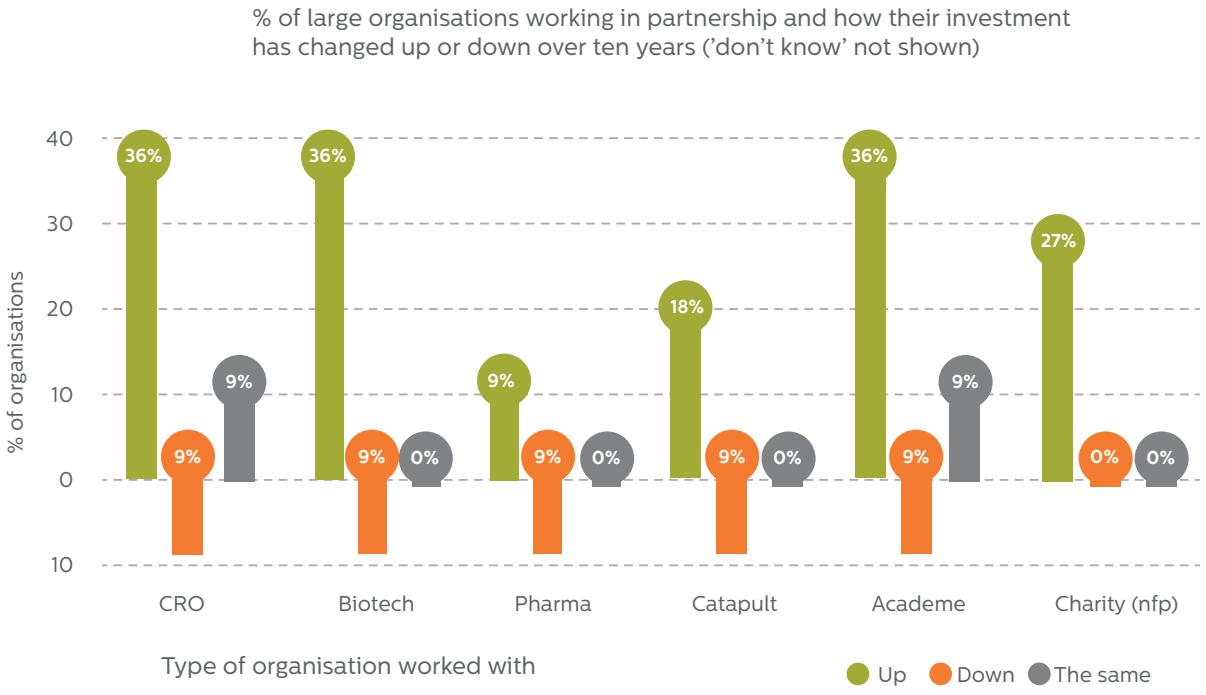
Collaborations with catapults, catalysts and discovery centres have seen the highest percentage of firms increase their investment.

Of large firms who reported collaborations with charities and not-for-profit organisations in the UK, none has decreased their investment over ten years.

> "Increased external collaboration with academe is important but should be seen as one approach among a range of others such as increased outsourcing and licensing".
>
> **Director, Research Centre – large pharmaceutical company**

Figure 30: How large firm collaboration investment has changed over ten years, by collaborator type.

All expressed as % of 11 large firms:
CRO n = 7 large firms who work with CROs
Biotech n = 7 large firms who work with Biotech firms
Pharma n = 2 large firms who work with Pharmaceutical firms
Catapult n = 3 large firms who work with Catapults
Academe n = 8 large firms who work with Academe
Charity (nfp) n = 8 large firms who work with Charities (nfp)



Source: TBR (Ref: W1/C2 and Piktochart)

6.3 Who is involved in drug discovery licence deals?

We analysed the number and nature of licencing deals for drugs at the discovery stages (Figure 31), as a key indicator of the changing nature of the drug discovery landscape.

From 2005 to 2015 we see an increase in the number of deals at the discovery stage where the licensor organisation is UK based. This trend is also seen when we look at all deals featuring UK based licensees (not charted). This corroborates the impression that licencing plays an increasingly important role in drug discovery activities in the UK.

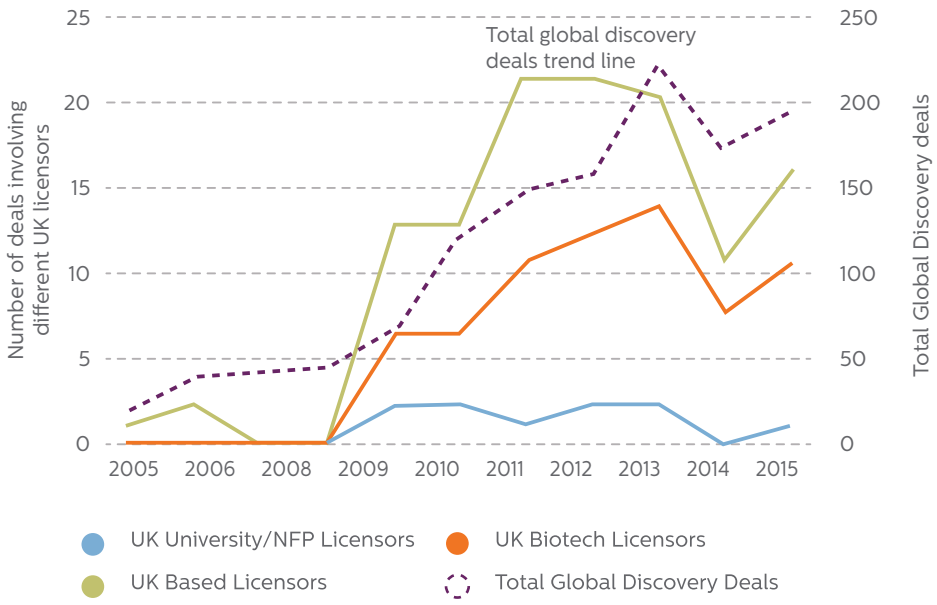
As shown in Figure 31, this pattern of increased licensing mirrors the general increase in total discovery stage deals around the world, suggesting that companies are increasingly investing in new assets at this early stage of development, as one approach to improving productivity.

The increase in UK based licensors appears to be particularly driven by an increase in licensing by UK based biotech firms – with 67% of all UK licensors in 2015 being biotech firms.

We have not seen a similar pattern in the number of UK based universities or not-for-profit organisations acting as licensors. This is in contrast to the global discovery deals trend which includes universities (separate data for US academic institutions not shown).

This could raise questions as to the prominence of entrepreneurial activity by UK universities in drug discovery. However, it may be that UK universities transact activities via a different model, such as through associated drug discovery centres, or spin out companies. This would merit further research. It is certain though, as we have identified through the survey data, that academe feature strongly in collaborations and partnerships made by large companies and drug discovery initiators in the UK. This may indicate that the nature of academic-industry interactions in the UK differ slightly from global trends, with collaborations and open innovation partnerships more important than direct licensing deals.

Figure 31: Discovery stage deals featuring UK licensors, and global trend, 2005-2015



Source: Biopharm Insights/CBSL/TBR

7 CONCLUSION

The evidence from the literature and from our survey results confirms that the UK drug discovery landscape has changed significantly in the last decade.

Whilst, almost all the largest UK drug discovery employees have decreased their in-house employment in the UK, our report also shows that many firms have actually increased overall investment in early drug discovery in the UK during this period. At least 60% of large organisations surveyed have increased outsourcing and collaborative investment in discovery in the UK in the last 10 years. This is reflected in largely increased employment and investment in discovery work by CRO, academic, and some small biotechnology firms in the UK in this period. For example, over 70% of surveyed CROs had increased commissioned discovery work, or begun trading, in the last 10 years.

It is therefore clear that the early drug discovery resource base in the UK is shifting and highly dynamic. There is a move from internal activity within UK-based large pharmaceutical companies to more globally networked multi-party outsourced and collaborative approaches.

Outsourcing and collaboration are now routinely embedded into drug discovery activities in the UK. Open innovation approaches, particularly involving academe and multi-party consortia, are an increasingly important element of companies' approach to early drug discovery.

This is not a new phenomenon, as both UK and non-UK headquartered pharmaceutical companies have led the way in working collaboratively with academe in the UK. The UK, through initiatives from companies such as GSK and AZ provided some of the early pioneers in sourcing innovation from academe. Examples include programmes such as GSK's Academic Alternative Discovery Initiative, setup in 2003, and AstraZeneca's Open Innovation Platform. A more recent example is UCB Pharmaceuticals' collaboration with the MRC to provide UK scientists access to UCB's novel high-throughput screening antibody capabilities for target discovery.

What is becoming apparent is that these collaborations are becoming truly two-way, with companies sharing assets and knowledge, in addition to investment, in open innovation approaches. These interactions are focused around target validation and fundamental understanding of the disease mechanism and its manifestations in clinical outcomes.

The UK has clearly adapted to many of these changes, with a thriving discovery CRO and academic sector, which attracts global investment from many companies.

Additionally, over 60% of pharmaceutical companies surveyed employ staff in the UK who coordinate discovery activities globally, and this number has increased in recent years. This demonstrates that the UK maintains a prominent global reach and responsibility for delivery of drug discovery.

However, this report also shows that overall more organisations, particularly large companies, are increasing investment overseas compared to the UK, suggesting there are still opportunities to build on and strengthen the UK's drug discovery landscape.

This report additionally identifies that there are key disciplines within drug discovery where the UK has certain strengths and weaknesses. For example, almost 60% of initiator companies do not conduct High Throughput Screening in the UK. It is also interesting that the majority of firms surveyed are small companies, employing less than 25 employees in UK drug discovery. It would be interesting to explore further the areas of expertise of these small companies, particularly of CROs, which attract global investment to the UK. These scientific strengths and gaps could be built on to further cement the UK's offering in a global drug discovery landscape.

The findings in this report raise some key challenges for how the current and future robustness of the UK early drug discovery landscape can be secured in a global market.

A consistent theme from the interviews was a concern over the long-term consequences of the trends identified in the report on drug discovery expertise in the UK. New drug discovery scientists benefit from exposure to a range of projects; an experience that is difficult to gain in small firms or academic programmes that are often working on a very limited number of drug assets. The shift in employment base therefore raises challenges for developing the next generation of drug discovery scientists. Such a shift may make it more difficult to gain the breadth of innovation, disease specific, and leadership expertise available to a previous generation.

As companies invest more externally and globally, are skill and capability gaps emerging in the UK? A number of interviewees indicated difficulty in recruiting certain disciplines, for example bioinformatics and experienced DMPK scientists.

Additionally, the biotech sector in the UK is seen as important for large pharma but information from the survey indicates that the sector has not been growing employment rapidly over the last 5-10 years, unlike CRO and academic organisations, so offers limited capacity to absorb any further release of expertise from pharmaceutical companies operating in the UK.

If the UK is viewed as a single integrated early drug discovery entity, the pattern of investment across and within the stakeholders will be crucial to maintaining a balanced ecosystem. The health of this system is vital to ensure improvements to the productivity of early drug discovery in providing innovative medicines for patient benefit and so that the UK maximises the retention of wealth that this activity creates.

8 TECHNICAL APPENDICES

8.1 Drug discovery definitions

8.1.1 Survey Form A: drug discovery initiators

Potential locations for drug discovery work in the UK are either:

- **In-house:** i.e. at a facility, laboratory, etc, owned and operated by the company
- **Externally:** i.e. at a facility, laboratory, etc, owned and operated by a different organisation

Organisations companies may partner/collaborate with or outsource to are:

- **CRO:** Contract research organisations provide support to the pharmaceutical, biotechnology, and medical device industries in the form of research services outsourced on a contract basis.
- **Biotech company:** Biotechnology companies are generally small private businesses which specialise in a limited number of therapeutic areas. Larger pharmaceuticals may collaborate with them and may see them as a source of new medicines.
- **Pharma company:** A large pharmaceutical company which discovers, develops, manufactures and markets medicines for human or animal health.
- **Catapult, catalyst or discovery centre:** These are generally publicly funded or business funded centres which act as a hub for R&D, providing a range of support from laboratory space, access to equipment or funding/business support. These generally aim to encourage innovation and to help take projects from research to commercial viability.
- **University or academe:** A university department or research institute.
- **Charity or not for profit:** A research centre or institute funded by a charity or not-for-profit organisation to undertake research into specific diseases (e.g. Cancer Research UK).

8.1.2 Survey Form B: drug discovery service providers

- **In-house:** i.e. at a facility, laboratory, etc, owned and operated by the company
- **Externally:** i.e. at a facility, laboratory, etc, owned and operated by a different organisation

Organisations companies may partner/collaborate with or outsource to are:

- **Customer facility or equipment:** As respondents in this survey often work on contracts for other businesses, their staff may work at their client's facility or on their equipment, i.e. facility, laboratory owned and operated by the organisation they are working for.
- **Academic facility or equipment:** This is where employees from organisations undertake work at facilities or laboratories in university departments or research institutes rather than in-house. For example, this may happen if the University is funding the research or is the only location of a specialist piece of equipment.
- **Catapult, catalyst or discovery centre:** This is where employees from organisations undertake work at facilities or laboratories in catapults, catalysts or discovery centres as described above.

8.1.3 Activity definitions

Term	Explanation
Assay Development	Process to develop an assay (typically a biological test) to be used in early drug discovery. For example, an assay that will form the basis of a HTS (see below) programme.
Drug discovery date	The overall process by which new candidate drugs are discovered. Usually involves: Target identification → target validation (TV) → assay development → high-throughput screening → Hit-to-Lead (H2L) → lead optimization (LO) to candi- selection Subsequent stages of preclinical and clinical testing are considered to form the development phase.
GLP	Good Laboratory Practice. This is an internationally recognised set of principles and standards under which information and data are generated and collected for lead drug candidates on their safety and efficacy. The data are included in the IND dossier sent to the regulatory authorities for approval.
High Throughput screening (HTS)	High Throughput Screening is a drug-discovery process widely used in the pharmaceutical industry. It uses automation to quickly assay the biological or biochemical activity of a large number of drug-like compounds (hundreds of thousands to millions).
Hit-to-Lead	Also known as lead generation, is about filtering the large numbers of positive hits identified in an HTS programme to a limited number of "lead" or promising candidates that are then subject to the next stage of the discovery process (lead optimisation).
IND	Investigational New Drug (application) the dossier of information submitted to the FDA (in the USA) before an investigational drug can be administered to humans. In the UK/Europe the equivalent approval is via a Clinical Trials Authorisation (CTA).
IP regulation	Intellectual Property, safeguarding of the IP associated with the design and manufacture of possible new drugs.
Lead optimisation	The process of optimising possible leads candidates that are identified in the Hit-to-Lead stage. Optimisation looks at improving the potency, safety, stability and metabolism of a lead by modifying its chemical structure.
Medicinal chemistry	The area where medicine and chemistry come together and is a discipline of chemistry involved in understanding the interaction of chemicals with biological systems. This includes both the design and synthesis of new molecules.
Molecular and cellular biology	Molecular and cellular biology combines genetics and biochemistry to understand life at the molecular level and it aims to explain how molecular function produces the hierarchy of living cells, tissues and ultimately whole organisms.

Term	Explanation
Non-GLP investigative safety/toxicity	Studies conducted outside the GLP regime aimed at establishing whether drugs are likely to be safe enough for humans. An early assessment of safety primarily focused on pharmacodynamic properties. A series of acute, chronic and genetic tests to determine gross toxicity effects.
Non-GLP Toxicity	Studies conducted outside the GLP regime aimed at establishing whether drugs are likely to be safe enough for humans. A series of acute, chronic and genetic tests to determine gross toxicity effects.
Pre-GLP	See GLP above. Pre-GLP will refer to work carried out before those studies that will generate data for regulatory purposes. As GLP carries a burden of rules and regulations, it won't be used formally until necessary.
R&D tax credits	Research and Development tax credits provide companies with allowances to set against possible Corporation Tax.
Target validation (TV)	The process in drug discovery after Target Identification that generates data that support the hypothesis that modifying this target by a drug could lead to a cure or reduce the effects of a disease.
Target-ID	Target identification. This is the first step in the drug discovery process that identifies which part of a cell within the body that a drug should be made to interact (target). Evidence is collated that points to the target as key to the process that leads to a disease and that by affecting this target with a drug the disease can by cured (e.g. as in cancer) or the effects of the disease reduced (e.g. in heart disease)
Therapeutic area	An area of medicine, eg oncology, gastrointestinal, cardiology etc.

8.2 Survey respondent breakdowns

8.2.1 Survey A: Early drug discovery initiators

Table 1: Breakdown of survey respondents by whether they undertake early drug discovery in the UK

Do you undertake early drug discovery in the UK?	Number of organisations
Yes- in-house and externally	30
Yes- externally only	9
Yes- In-house only	9
No	7
Total	55

Source: TBR Ref W1/S12/T1

Table 2: Breakdown of survey respondents by total employment

Total employment (from consultant database)	Number of organisations
1 to 49	34
50-249	4
250+	11
Unknown (no data)	6
Total	55

Source: TBR Ref W1/S12/T2

Table 3: Breakdown of survey respondents by type

Organisation type	Number of organisations
Biotech	25
Pharmaceuticals	20
Academe	6
Contract Research	4
Total	55

Source: TBR Ref W1/S12/T3

8.2.2 Survey B: Early drug discovery service providers

Table 4: Breakdown of survey respondents by whether they undertake early drug discovery in the UK

Do you undertake early drug discovery in the UK?	Number of organisations
Yes	30
No	0
Total	30

Source: TBR Ref W1/S12/T3

Table 5: Breakdown of survey respondents by total employment

Total employment (from consultant database)	Number of organisations
1 to 49	17
50-249	7
250+	1
Unknown (no data)	5
Total	30

Source: TBR Ref W2/S7/T2

Table 6: Breakdown of survey respondents by type

Do you undertake early drug discovery in the UK?	Number of organisations
CRO	28
Academe	2
Total	30

Source: TBR Ref W2/S7/T3

8.3 Survey forms

Both survey forms opened with an introduction screening question to confirm which survey the company being interviewed should complete, i.e. to ascertain if they were an initiator or service provider. This introduction and screening section read as follows:

When involved in drug discovery does your organisation (a) initiate the drug discovery work OR (b) mainly work under contract from other organisations or in partnership with other organisations which initiate the work?

If (a) continue with Survey Form A. If (b) use with Survey Form B.

We appreciate that you may not be able to provide all the information requested and we would very much appreciate your response to as many questions as possible as this will still be valuable to our research. Please be assured that your survey responses will be stored anonymously in keeping with data protection legislation. Survey responses will be analysed and reported at an aggregate level and individual organisations will not be identified. Calls will be recorded for our internal quality purposes only. Is this OK?

8.3.1 Survey Form A: Drug discovery initiators

Q number	Question	Answer options	Routing
Q1	**Does your organisation conduct activities associated with early drug discovery(pre-GLP or IND enabling studies) in the UK (either In-house or externally)?** This question is to distinguish early drug discovery (target ID, target validation, Hit-to-Lead and lead optimisation) from IND-enabling studies (carried out to GLP)	1. No 2. Yes - In-house only 3. Yes - externally only 4. Yes - in-house and externally If no – Q1b	If yes 2. or 4. – go to Q2 If yes 3. go to Q3
Q1b	Do you undertake any early drug discovery work either In-house or externally elsewhere around the world?	Yes / No If no – go to Q1d	If yes – continue
Q1c	In which regions do you do this work?	Please select all that apply: Other Europe North America South America Asia Other (specify)	Continue
Q1d	Has your organisation previously conducted drug discovery in the UK?	Yes / No If no – go to end	If yes – continue
Q1e	What were the reasons for your organisation stopping its involvement in drug discovery in the UK?	Please select all that apply from the following: Other regions more attractive due to: • Enabling environment e.g. science base • Better environment for collaboration with public and private partners • More supportive institutional environment (e.g. IP regulation, R&D tax credits etc) • Business reasons (e.g. location of HQ) • Quality and availability of skilled people • Proximity to market • Other (please specify)	Go to end

Q number	Question	Answer options	Routing
Q2	**Approximately, how many staff are involved in your organisation's early discovery activity 'in-house' – i.e. at a facility in the UK?**	Please select a range: 1-10 10-25 25-50 50-100 100-250 250-500 500+	Continue
Q2a	Approximately what proportion of your organisation's total UK staff are involved in your organisation's early discovery activity in the UK?	Please select a range: 1%-25% 1%-25% 1%-25% 76%-100%	Continue
Q2b	Has the number of your organisation's staff working on in-house early drug discovery in the UK changed compared to **five** years ago?	Stayed the same Stayed the same Gone up a little (<25%) Gone up a lot (25%+) Gone down a little (<25%) Gone down a lot (25%+) Don't know/skip	Continue
Q2c	Has your number of organisation's staff working on in-house early drug discovery in the UK changed compared to **ten** years ago?	Stayed the same Gone up a little (<25%) Gone up a lot (25%+) Gone down a little (<25%) Gone down a lot (25%+) Don't know/skip	Continue
Q2d	What is the number of sites involved?	Numerical free response	Continue
Q2e	Is this more or fewer than **five** years ago?	More Less The same Don't know	Continue
Q2f	Is this more or fewer than **ten** years ago?	More Less The same Don't know	If answered Q1 2. Yes in-house – go to Q4 If answered Q1 4.Yes - continue

Q number	Question	Answer options	Routing
Q3	**Which types of organisations do you work with when undertaking early drug discovery work externally with a partner or collaborator in the UK?**	Select all that apply: • CRO • Biotech company • Pharma company • Catapult, catalyst or discovery centre • University or academia • Charity or not for profit	Continue
Q3a	What is the nature of this partnership or collaboration?	• Precompetitive collaboration with academia or industry. • One-to-one collaboration involving academia or not-for-profit organisation focused on a commercial relevant target or activity (as opposed to underpinning pre-competitive research) • One-to-one collaboration involving biotech or pharmaceutical company focused on a commercial relevant target or activity (as opposed to underpinning pre-competitive research) • Multi-party collaboration of with academe or not-for-profit organisations focused on a commercial relevant target or activity (as opposed to underpinning pre-competitive research) • Multi-party collaboration of with biotech or pharmaceutical companies focused on a commercial relevant target or activity (as opposed to underpinning pre-competitive research) • Other (please specify)	Continue
Q4	**Which of the following activities and or disciplines of early discovery work are you engaged with in the UK?**		
Q4a	Target identification	Please select all that apply: In-house Outsourced Collaboration Not conducted in the UK	Continue

Q number	Question	Answer options	Routing
Q4b	Target validation	Please select all that apply: In-house Outsourced Collaboration Not conducted in the UK	Continue
Q4c	Medicinal chemistry	Please select all that apply: In-house Outsourced Collaboration Not conducted in the UK	Continue
Q4d	Molecular and cellular biology	Please select all that apply: In-house Outsourced Collaboration Not conducted in the UK	Continue
Q4e	Assay Development	Please select all that apply: In-house Outsourced Collaboration Not conducted in the UK	Continue
Q4f	Non-GLP Toxicity	Please select all that apply: In-house Outsourced Collaboration Not conducted in the UK	Continue
Q4g	Hit-to-Lead identification	Please select all that apply: In-house Outsourced Collaboration Not conducted in the UK	Continue
Q4h	High Throughput screening (HTS)	Please select all that apply: In-house Outsourced Collaboration Not conducted in the UK	Continue
Q4i	Non-GLP Investigative Safety/Toxicology	Please select all that apply: In-house Outsourced Collaboration Not conducted in the UK	Continue

Q number	Question	Answer options	Routing
Q4j	Other activities or functions	Please select all that apply: In-house Outsourced Collaboration Not conducted in the UK	Continue
Q5	**How has the overall amount of resource invested by your organisation in early drug discovery in the UK (both internally and externally) changed over the last ten years? (this includes all resources: staff, materials, capital etc.)**	Stayed the same Gone up a little (<25%) Gone up a lot (25%+) Gone down a little (<25%) Gone down a lot (25%+)	Continue
Q5a	How has the overall amount of resource invested in early drug discovery by your organisation **globally** changed over the last ten years?	Stayed the same Gone up a little (<25%) Gone up a lot (25%+) Gone down a little (<25%) Gone down a lot (25%+)	Continue
Q6	**How has the level of your organisation's investment in in-house early drug discovery in the UK changed over the last ten years?**	Stayed the same Gone up a little (<25%) Gone up a lot (25%+) Gone down a little (<25%) Gone down a lot (25%+)	Continue
Q6a	How has the level of your organisation's investment in in-house early drug discovery **globally** changed over the last ten years?	Stayed the same Gone up a little (<25%) Gone up a lot (25%+) Gone down a little (<25%) Gone down a lot (25%+) Not relevant – we don't undertake early drug discovery outside the UK	Continue
Q7	**How has the level of your organisation's investment in outsourcing early drug discovery changed over the last ten years in the UK?**	Stayed the same Gone up a little (<25%) Gone up a lot (25%+) Gone down a little (<25%) Gone down a lot (25%+) Not relevant – we don't outsource drug discovery in the UK	Continue

Q number	Question	Answer options	Routing
Q7a	How has the level of your **organisation's** investment in outsourcing early drug discovery changed **globally** over the last ten years?	Stayed the same Gone up a little (<25%) Gone up a lot (25%+) Gone down a little (<25%) Gone down a lot (25%+) Not relevant – we don't outsource drug discovery globally	Continue
Q8	**How has the level of your organisation's investment in collaborative early drug discovery changed in the UK over the last ten years?**	Stayed the same Gone up a little (<25%) Gone up a lot (25%+) Gone down a little (<25%) Gone down a lot (25%+) Not relevant – we don't collaborate on drug discovery in the UK	Continue
Q8a	How has the level of your **organisation's** investment in collaborative early drug discovery changed **globally** over the last ten years?	Stayed the same Gone up a little (<25%) Gone up a lot (25%+) Gone down a little (<25%) Gone down a lot (25%+) Not relevant – we don't collaborate globally on drug discovery	Continue
Q9	**In addition to the practical early discovery work conducted by your organisation, do any of your organisation's UK staff perform a coordination or managerial role for early discovery work conducted outside of the UK (either internally or externally)?**	Yes / No	If yes – continue If no – go to end
Q9a	How many of your organisation's staff in the UK perform a coordination or managerial role for early discovery work conducted **internally by your organisation or externally by other organisations outside** of the UK?	Please select a range: 1-10 10-25 25-50 50-100 100+	Continue
Q9b	Has this number of staff changed compared to **ten** years ago?	Stayed the same Gone up a little (<25%) Gone up a lot (25%+) Gone down a little (<25%) Gone down a lot (25%+) Don't know/skip	Continue

Q number	Question	Answer options	Routing
Q9c	In which regions outside of the UK does your organisation conduct this early drug discovery work?	Please select all that apply: Other Europe North America South America Asia Other (specify)	Continue

8.3.2 Survey form B: Drug discovery service providers

Q number	Question	Answer options	Routing
Q1	**Does your organisation conduct activities associated with early drug discovery (pre-GLP or IND enabling studies) in the UK (either In-house or externally)?** This question is to distinguish early drug discovery (target ID, target validation, Hit-to-Lead and lead optimisation) from IND-enabling studies (carried out to GLP)	1. No 2. Yes	If Yes – go to Q2 If no – continue
Q1b	Do you undertake any early drug discovery work either In-house or externally elsewhere around the world?	Yes / No	If yes –continue If no – go to Q1d
Q1c	In which regions do you do this work?	Please select all that apply: • Other Europe • North America • South America • Asia • Other (specify)	Continue
Q1d	Has your organisation previously conducted drug discovery in the UK?	Yes / No	If yes – continue If no – go to end

Q number	Question	Answer options	Routing
Q1e	What were the reasons for your organisation stopping its involvement in drug discovery in the UK?	Please select all that apply from the following: Other regions more attractive due to: • Enabling environment e.g. science base • Enabling environment e.g. science base • Better environment for collaboration with public and private partners • More supportive institutional environment (e.g. IP regulation, R&D tax credits etc) • Business reasons (e.g. location of HQ) • Quality and availability of skilled people • Proximity to market • Other (please specify)	Go to end
Q2	**Approximately, how many staff are involved in your organisation's early discovery activity 'in-house' in the UK?**	• Please select a range: • 1-10 • 10-25 • 25-50 • 50-100 • 100-250 • 250-500 • 500+	Continue
Q2a	Has the number of your organisation's staff working in early drug discovery in the UK changed compared to **five** years ago?	• Stayed the same • Gone up a little (<25%) • Gone up a lot (25%+) • Gone down a little (<25%) • Gone down a lot (25%+) • Don't know/skip	Continue
Q2b	Has the number of your organisation's staff working in early drug discovery in the UK changed compared to **ten** years ago?	• Stayed the same • Gone up a little (<25%) • Gone up a lot (25%+) • Gone down a little (<25%) • Gone down a lot (25%+) • Don't know/skip	Continue

Q number	Question	Answer options	Routing
Q3	**Which types of organisations engage you in drug discovery work? (I.e. who initiates your discovery work?)**	Please select all that apply from list: • Contract Research Organisation • Biotech company • Pharma company • Catapult or discovery centre • Charity or not for profit • Academic drug discovery centre / university • Other (specify)	Continue
Q3a	How are you engaged by these organisations?	Please select all that apply list: Select all which apply: • Precompetitive collaboration with academia or industry. • One-to-one collaboration involving academia or not-for-profit organisation focused on a commercially relevant target or activity (as opposed to underpinning pre-competitive research) • One-to-one collaboration involving biotech or pharmaceutical company focused on a commercially relevant target or activity (as opposed to underpinning pre-competitive research) • Multi-party collaboration of with academe or not-for-profit organisations focused on a commercially relevant target or activity (as opposed to underpinning pre-competitive research) • Multi-party collaboration of with biotech or pharmaceutical companies focused on a commercially relevant target or activity (as opposed to underpinning pre-competitive research) • Other (please specify)	Continue

Q number	Question	Answer options	Routing
Q3b	Where are these organisations based?	Please select all that apply: • UK • Other Europe • North America • South America • Asia • Other (specify)	If UK only – go to Q4 Else - continue
Q3c	Approximately what proportion of your work is conducted for organisations where your primary point of conduct is based outside of the UK?	• 0-25% • 26-50% • 51-75% • 76-100%	Continue
Q3d	Has the proportion of your work conducted for organisations where your primary point of conduct is based outside of the UK increased or decreased during the last five years?	• Stayed the same • Gone up a little (<25%) • Gone up a lot (25%+) • Gone down a little (<25%) • Gone down a lot (25%+) • Don't know	Continue
Q4	**Does your early drug discovery in the UK activity focus on any specific therapeutic areas? If so, which?**	Please list all that apply. Or Unable to say.	Continue
Q5	**Which of the following fields of discovery work are you engaged with in the UK?**		
Q5a	Target identification	Please select all that apply: In-house Outsourced Collaboration Not conducted in the UK	Continue
Q5b	Target validation	Please select all that apply: In-house Outsourced Collaboration Not conducted in the UK	Continue

Q number	Question	Answer options	Routing
Q5c	Medicinal chemistry	Please select all that apply: In-house Outsourced Collaboration Not conducted in the UK	Continue
Q5d	Molecular and cellular biology	Please select all that apply: In-house Outsourced Collaboration Not conducted in the UK	Continue
Q5e	Assay Development	Please select all that apply: In-house Outsourced Collaboration Not conducted in the UK	Continue
Q5f	Non-GLP Toxicity	Please select all that apply: In-house Outsourced Collaboration Not conducted in the UK	Continue
Q5g	Hit-to-Lead identification	Please select all that apply: In-house Outsourced Collaboration Not conducted in the UK	Continue
Q5h	High Throughput screening (HTS)	Please select all that apply: In-house Outsourced Collaboration Not conducted in the UK	Continue
Q5i	Lead optimisation	Please select all that apply: In-house Outsourced Collaboration Not conducted in the UK	Continue

Q number	Question	Answer options	Routing
Q6	**How have your organisation's levels of UK-based drug discovery activity commissioned by other organisations changed in the last 10 years?**	Stayed the same Gone up a little (<25%) Gone up a lot (25%+) Gone down a little (<25%) Gone down a lot (25%+)	Continue
Q7	**How have your organisation's levels of UK-based drug discovery activity (as measured by resource investment) changed in the last 10 years?**	Stayed the same Gone up a little (<25%) Gone up a lot (25%+) Gone down a little (<25%) Gone down a lot (25%+)	Continue
Q8	**Do you ever undertake drug discovery work at UK facilities other than your own?**	Yes / No	If yes – continue If no – go to end
Q8a	What type of facilities are these?	- Customer facility or equipment - Academic facility or equipment - Catapult, catalyst or discovery centre	Continue