The Bioeconomy Consultants
NNFCC

Industrial Biotechnology in the UK

Anecdotal Insights from Two Years of the Industrial Biotechnology Barometer Survey

Prepared for the Industrial Biotechnology Leadership Forum

July 2024

Release Date: July 2024

Author: Dr Adrian Higson Lead Consultant Biobased Products

Reviewer: Sophie Mason Senior Consultant

Background

This briefing document was compiled using information and comments provided through the Industrial Biotechnology Barometer Survey. Supporting information is available on request and NNFCC consultants are available for further discussion.

Disclaimer

NNFCC is a leading international consultancy with expertise on the conversion of biomass to bioenergy, biofuels and biobased products.

The Bioeconomy Consultants
NNFCC

NNFCC, Biocentre,
York Science Park,
Innovation Way,
Heslington,
York, YO10 5NY

Phone: +44 (0)1904 435182
Fax: +44 (0)1904 435345
Email: enquiries@nnfcc.co.uk
Web: www.nnfcc.co.uk

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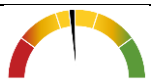
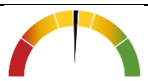
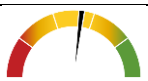
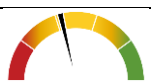
1 Summary

The Industrial Biotechnology (IB) Barometer Survey is managed by NNFCC on behalf of the Industrial Biotechnology Leadership Forum (IBLF).

The results of the survey aim to inform and support the development of industrial biotechnology policy in the UK. The survey is deliberately based on small sample of engaged executives and senior managers. This small sample size means that results should not be taken as conclusive findings but are intended to provide an indication of areas that warrant further study.

The table below summarises the response to the first four rounds of the survey which took place from autumn 2022 to spring 2024.

Table 1: Summary of survey responses.

Innovation function	Performance Rating [1]	Perceived change in performance compared to 12 months ago [2]			
Reference Survey	**Spr 24**	**Aut 22**	**Spr 23**	**Aut 23**	**Spr 24**
Knowledge generation		↑	↓	↓	↓
Fundamental research					
Industrial research					
Technology pilot and demo					
Knowledge Exchange		↓	↑	→	↑
Resources		↓	↓	↓	↓
Legitimacy		↑	↑	↑	↑
Entrepreneurial activity		↓	→	→	→
Direction of travel		↓	↓	→	↑
Market formation		↓	↓	↓	→

[1] Based on a rating of 1-5 where 1 = poor and 5 = excellent: 

[2] Each arrow represents a survey (in chronological order). Arrows indicate the view of respondents (mean of responses). ↓ decrease in performance, → no change, ↑ improvement in performance.

2 Background

The Industrial Biotechnology (IB) Barometer Survey is managed by NNFCC on behalf of the Industrial Biotechnology Leadership Forum (IBLF). The results of the survey aim to inform and support the development of industrial biotechnology policy in the UK.

The survey is circulated twice a year to a select group of UK stakeholders active at a senior level across the industrial biotechnology sector.

The survey is based on the concept of the "innovation system" – the need for a flow of technology and information among people, enterprises, and institutions; and the interactions between stakeholders required to turn an idea into a process, product, or service placed on the market.

The survey was first conducted in the Autumn of 2022, again in Spring 2023, in Autumn 2023, and in Spring 2024.

This report summaries the responses to these surveys and presents the anecdotal reasoning behind stakeholder responses.

3 Stakeholder Group

The survey is deliberatively circulated to a selective group of stakeholders comprised of executives and senior managers from within the IB community.

The four rounds of the survey generated 64 responses, with a completion rate of 92%. The typical time spent completing the survey was 15 minutes & 8 seconds.

The selected stakeholder group included representatives from across IB markets. It also includes research and technology organisations (RTOs), considered essential in the commercialisation of IB processes and products (Figure 1).

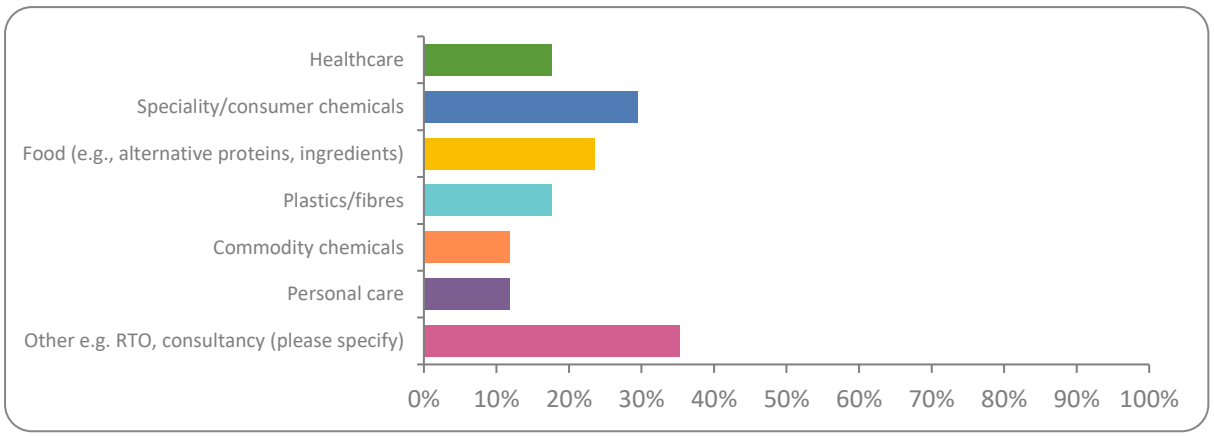


Figure 1: Breakdown of respondents to the Spring 2024 survey by market sector.

4 Innovation systems

The survey is based on the concept of "innovation systems". Innovation can be considered to occur within an ecosystem, with multiple stakeholders performing a range of actions, all of which play an important role in the innovation process. Identifying flaws and bottlenecks within innovation systems can lead to increased levels of innovation at a regional and national level, as well as within individual businesses.

An innovation system is built from key components which provide structure for the system. These components include the system's actors i.e., the organisations contributing to a technology, as a developer or adopter, or indirectly as a regulator or financier; or the institutions, which lie at the core of the ecosystem providing the rules and boundaries in which the system operates. Formal institutions include governmental laws and policy, but informal institutions that reflect societal morals, values and ethics are also important. The third component of the system are technological factors which define and constrain the system by means of costs, safety or reliability.

The innovation system relies on seven inextricably linked system functions, discussed below.

A **legitimacy of development** is required and guides the direction of activities that shape the needs, requirements and expectations of the actors within the innovation system (termed the direction of travel/search). Reaching consensus on the direction of the search enables effort to be focussed on specific technological options allowing for the strategic deployment of limited resources.

Any innovation will face a degree of **resistance to change**. The extent to which advocacy coalitions are formed is dependent on the nature of the change and the implications for market incumbents or society in general. Recent debates around food versus fuel and the use of genetically modified organisms demonstrate the importance of positive or negative advocacy coalitions for innovation.

A clear direction of search creates the necessary conditions for **knowledge development**. Knowledge development relies on a range of disciplines and expertise, and effective knowledge exchange is critical. **Knowledge exchange** and knowledge diffusion can be facilitated through the effective organisation and support of formal networks, through meetings, workshops and conferences, or through project collaborations.

Like any activity, innovation requires **resources**. The assessment of resource mobilisation looks at the allocation of financial, material, and human capital within the innovation system. Resource requirements will vary depending on the nature of the innovation and its point of development, but will include technical skills, finance and subsidies, infrastructure (such as educational systems and technology scale up facilities), and raw materials for manufacturing.

Without an innovation sponsor, emerging technologies will struggle to compete against incumbent technologies. **Market formation** considers the activities that contribute to the creation of a demand for the emerging technology. Market formation may involve financial support for the emerging technologies or taxing the use of competing technologies. It may also involve the development of standards and labels or mandating the supply of a product.

Finally, delivering technical developments to the market requires **entrepreneurial activity**. Projects need to prove the commercial attractiveness of the emerging technology in a practical environment. Access to finance (both internal and external) rests on the entrepreneur's ability to demonstrate the commercial viability and economic payback of the innovation.

The relative importance of each of these system functions will change depending on the specific actor and the maturity of the technology and/or application.

4.1 Relative Importance of Innovation Functions to UK IB

Respondents were asked to rank the importance of the following system functions, in terms of their UK based IB development activities:

- Support for *knowledge generation* (research and development).
- Ensuring the *legitimacy* (as a positive change for good) of industrial biotechnology and bioeconomy development.
- Access to *resources* (skills, infrastructure, capital, etc.).
- Ensuring effective and efficient *knowledge diffusion* from knowledge generators to users.
- Support for *entrepreneurial activity* (business creation and development).
- Clarity in the UK's policy framework (*direction of travel*) for the innovation space.
- Development of a UK *market* for processes or products.

As would be expected, views on the relative importance of system functions varied between respondents (Figure 2). Access to resources is ranked high by the majority of respondents (ranked 1st or 2nd by 70% of respondents in the spring 2024 survey), although not unanimously high by all respondents. Other highly ranked functions include knowledge generation, clarity of policy frameworks, and development of the UK market.

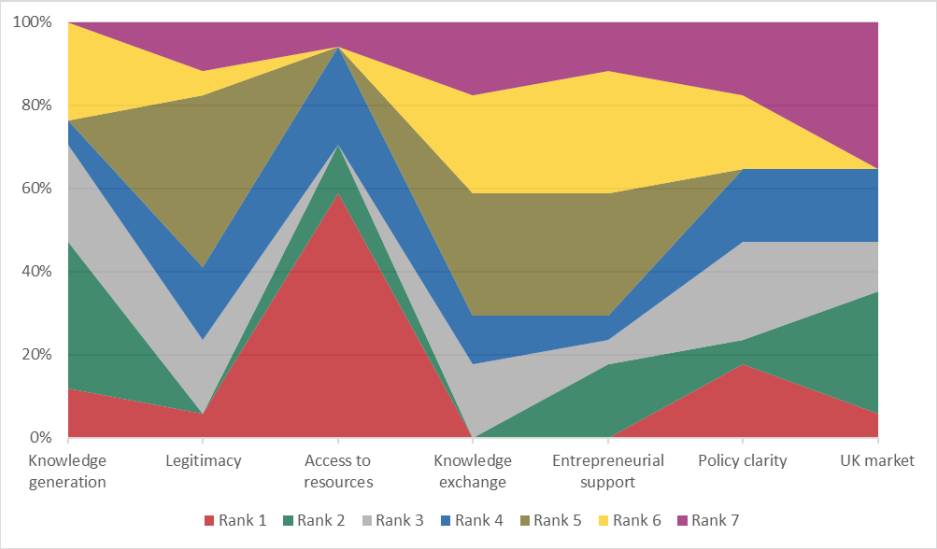


Figure 2: Respondent views on the relative importance of innovation system functions (% of respondents from the spring 2024 survey).

It is worth noting that although development of the UK market rated 1st or 2nd by around one third of respondents, another third of respondents ranked it as the least important function. This split in ranking across stakeholders likely reflects whether the respondent has a focus on UK or international markets.

5 Function Performance

5.1 Knowledge Generation

We asked respondents to "*rate (from 1 to 5, with 1 being poor, and 5 being excellent) the UK's ability to generate new knowledge for the support of their IB innovation space*". The response was positive with mean ratings above 3.3 across the four surveys (Figure 3).

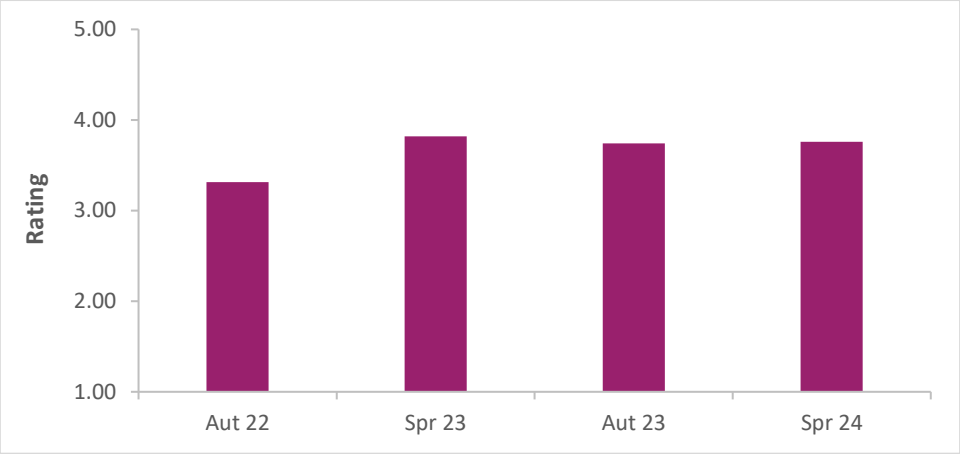


Figure 3: Rating of the UK's ability to generate new knowledge (mean ratings shown, with 1 being poor, and 5 being excellent).

When asked if their "*ability to access expertise and generate knowledge is currently better, worse, or around the same compared to 12 months ago?*", the responses reinforced that function performance has largely remained the same across the survey time period. Although some respondents indicated a worsening situation, which was offset by other respondents who believed that the situation was improving. The mean rating for this question in Spring 2024 was 1.82 (where 1 is better, 2 the same, and 3 worse).

Respondent Commentary

In the autumn 2022 survey, respondents commented on a reduction in international collaboration, challenges in international recruitment, and an unsettled political landscape. Comment was passed on the need to be networked to gain visibility of grant funding opportunities, and the limited availability of industry grant funding from Innovate UK. The economic downturn and its impact on private finance was also cited as a negative pull on research and knowledge generation. However, one respondent did indicate a clear impetus in the University space.

In the spring 2023 survey, some respondents saw an improving situation and cited a groundswell in IB activity and an increase in BBSRC/Innovate UK funding.

In autumn 2023, the UK's joining of Horizon Europe was cited as reason for an improving situation, although accessing European funds was still considered difficult by one respondent.

In spring 2024, multiple respondents cited the "National Vision for Engineering Biology" and the associated funding budget as a reason to believe that the IB landscape was improving.

We asked respondents to *"rate (1 to 5, where 1=very poor, 2=poor, 3=fair, 4=good, and 5=excellent) the performance of UK's research and translational ecosystem at the various stages of technology development in their area of industrial biotechnology*." Across the four surveys, respondents made a clear and consistent differentiation on the performance of the research and technology development system at different technology readiness levels (Figure 4). Fundamental research is seen as good to excellent, whereas industrial research is considered fair to good, and technology piloting/demonstration is seen as very poor to fair.

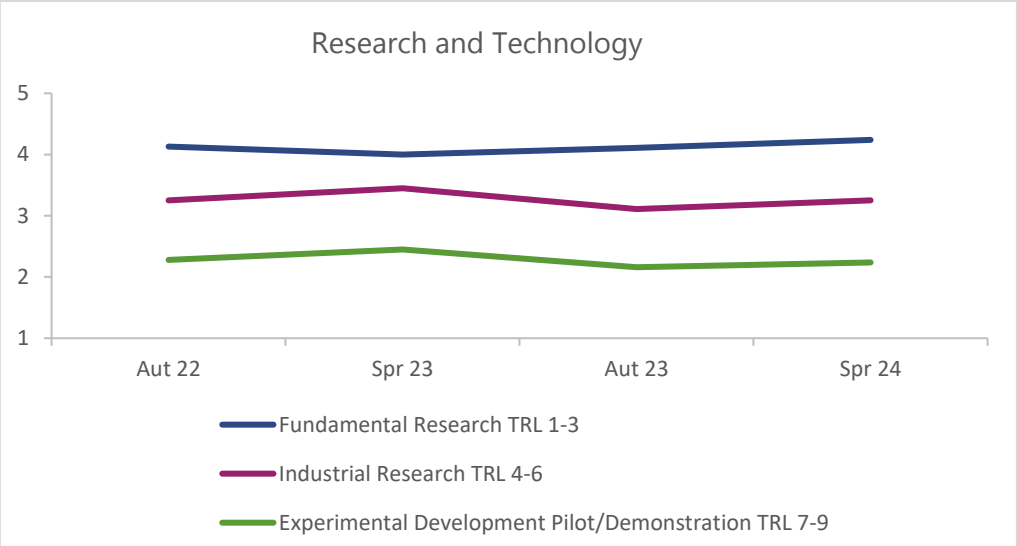


Figure 4: Rating of knowledge generation system by technology readiness group, (1=very poor, 2=poor, 3=fair, 4=good, 5=excellent), (mean of respondent scores).

5.2 Knowledge Exchange

We asked respondents to rate (1 to 5, with 1 being poor, and 5 being excellent) the "*UK's effectiveness in networking, building research collaboration, communicating and discussing research, and disseminating research outputs*" (Figure 5). Respondents were generally positive in regard to knowledge exchange, with a particularly positive response noted in the spring 2024 survey.

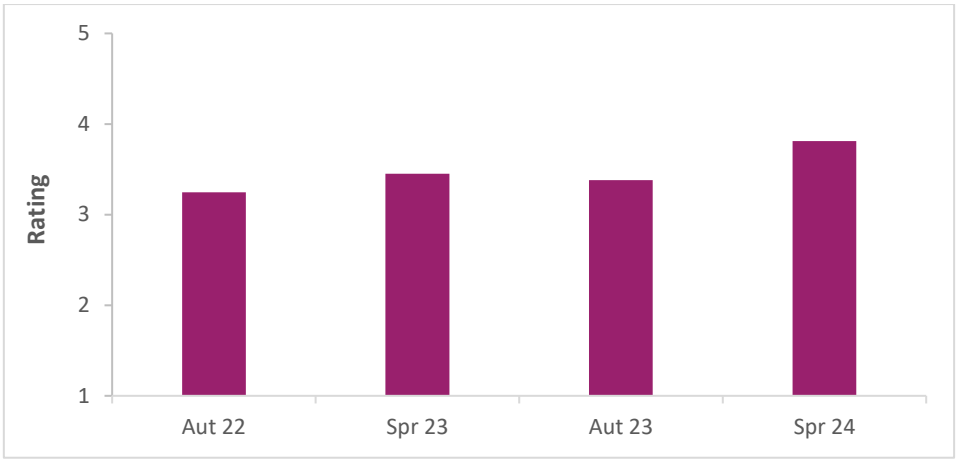


Figure 5: Rating of the knowledge exchange system (mean ratings shown, with 1 being poor and 5 being excellent).

Respondents were asked if their "*ability to access research knowledge and build research collaborations is currently better, worse, or about the same compared to 12 months ago?*". The response, reinforced by the rating score, showed that performance has slightly improved across the survey time period.

Respondent Commentary

In the autumn 2022 survey, several respondents pointed to Brexit and concerns over collaboration and knowledge exchange with European stakeholders, a lack of access to Horizon Europe was also cited as a key concern. However, one respondent pointed to the UK's ability create opportunities for knowledge exchange and the small distances between knowledge centres which makes for easy and efficient knowledge exchange.

In the spring 2023 survey, respondents pointed to a return to networking post-Covid and an increase in Innovate UK funding that has fostered new collaborations.

Respondents to the 2023 autumn survey, pointed to the return of pre-Covid levels of engagements and networking with the benefit of people being comfortable with a mixture of online and in-person meetings. Additionally, joining Horizon Europe was seen as improving knowledge exchange.

In the spring 2024 survey, respondents pointed to the UK's ability to communicate its science, although this generally relates to potential, with a persistent challenge being that there are too few positive news stories to disseminate in terms of commercial success. There was also a concern that the gap between university research and getting products to commercial or pilot scales is becoming larger. Respondents also pointed to a perception within certain areas of the UK community that participation in Horizon Europe is difficult, which creates a reluctance to join proposals. One respondent commented that the UK's extensive networks and support organisations/initiatives is well placed to ensure that effective dialogue can take place, but that funding is required to maintain these support mechanisms.

5.3 Resources

Respondents were asked to rate (1 to 5, with 1 being poor, and 5 being excellent) their perspective on the "*availability/accessibility of resources in the UK*" (Figure 6). Respondents indicated a declining ability to access the required resources across the last three surveys (spring 2023 to spring 2024).

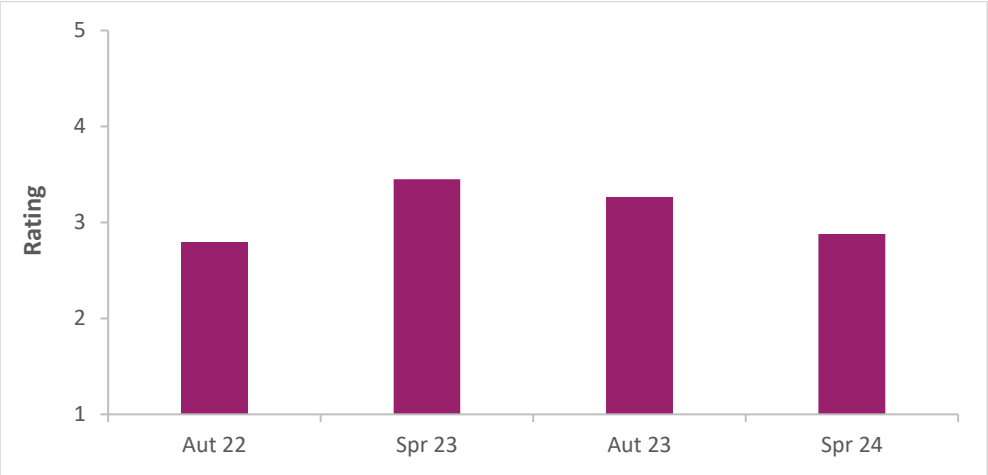


Figure 6. Rating of accessibility of resources available in the UK (mean ratings shown, with 1 being poor and 5 being excellent).

Respondents were asked whether their "*ability to access the resources they need is currently better, worse, or about the same compared to 12 months ago?*". Each survey returned a mean score of over two, indicating the view that accessibility had remained the same or become worse.

Resource requirements are manifold, and include finance, skills and facilities. Respondents were asked to "*indicate how challenging (1 to 3, 1=not at all, 2=moderately, 3=extremely) it is to access various resources*" (Figure 7). Responses indicated that access to funding and facilities for laboratory research is not considered an inhibiting challenge, whereas recruitment and accessing the funding and facilities to undertake scale-up work is a significant challenge. The ephemeral nature of Innovate UK funding for IB is also reflected in the responses on grant funding for industrial (business led) research projects.

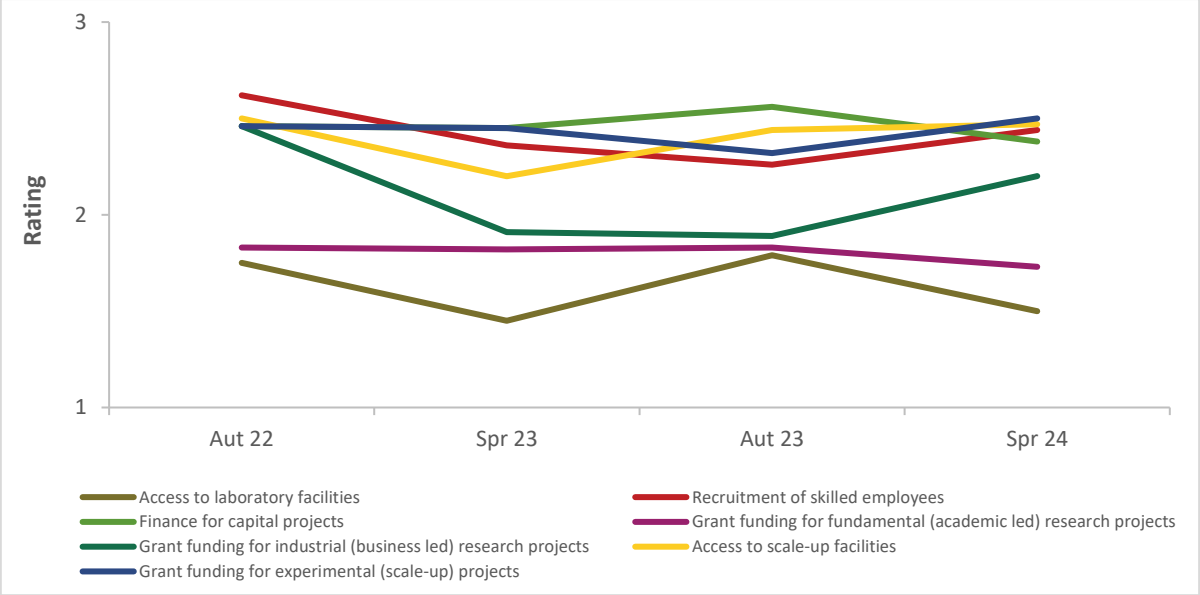


Figure 7. Resource accessibility, by type (mean of responses, 1=not at all, 2=moderately, 3=extremely challenging).

Respondent Commentary

Respondents to the spring 2023 survey pointed to staff recruitment hurdles post Brexit and the negative economic climate as creating resource challenges.

In the autumn 2023 survey, respondents highlighted an increase in Innovate UK funding, although one respondent was cautious that this could be a one-off event. Skills were discussed as a challenge, with securing and retaining resources an increasing problem in the UK. Brexit and restrictions on overseas talent were cited as underlying causes. One respondent stated that the UK was no longer relevant in regard to scaling and demonstrating processes and technologies.

The spring 2024 survey highlighted access to investment as a particular challenge, alongside the access and funding for scale and pilot activities. There were contradictory views on access to skills and labour, with one respondent highlighting continued challenges while another believed that the labour market was improving.

5.4 Legitimacy

Respondents were asked, from their perspective, to "*rate (1 to 5, with 1 being very negative, and 5 being very positive) the perception of key stakeholders (policymakers, politicians, citizens) to their area of industrial biotechnology.*" Across the timeframe of the surveys, respondents felt that the perceived legitimacy of IB had improved, moving from a slightly negative to a slightly positive position.

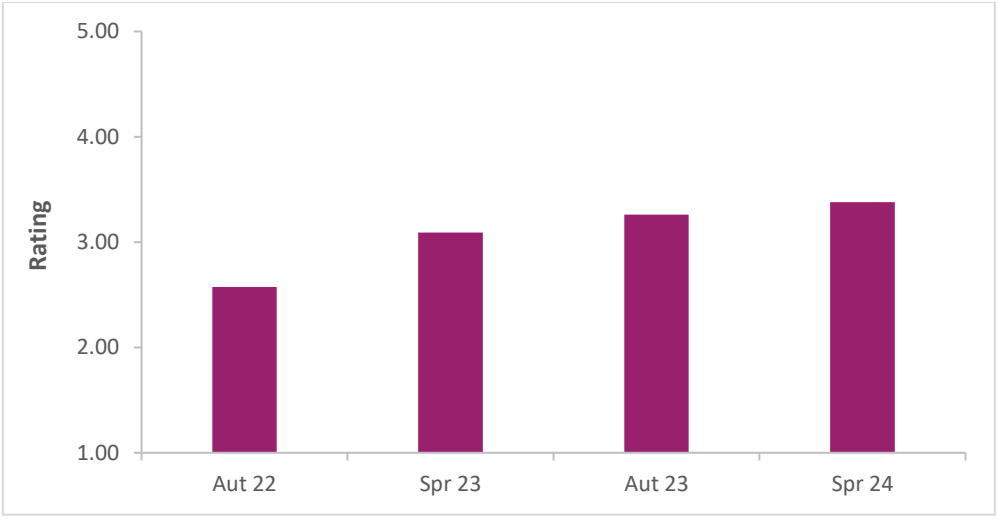


Figure 8. Rating of IB legitimacy (mean rating, with 1 being very negative, and 5 being very positive).

Respondents were asked "*if the legitimacy of the IB sector is currently better, worse, or about the same compared to 12 months ago.*" Across the survey, the mean score for this question ranged between 1.64 and 1.74 (where 1=better, 2=about the same, 3=worse), which reinforces that there has been a perceived improvement in the legitimacy of IB.

In respect to key stakeholders, we asked "*which stakeholders are considered the most important in determining the legitimacy of IB innovations in your innovation space?*". The stakeholder groups considered are:

- Politicians
- Citizens
- Policy makers
- Academics
- NGOs/charities
- Other

Respondents consistently considered politicians, citizens and policy makers to be key. Whereas academics, NGOs/charities and other (identified as other industries) were considered less important.

Respondent Commentary

Feedback from the initial survey pointed towards low awareness and understanding of the potential of IB amongst the public and government. Historic apprehension and aversion to GMOs were cited as reasons here. However, the deployment of Covid vaccines and alternative proteins may have positively increased awareness of the IB sector. There was a belief that GMOs will become more widely accepted in services/products, and that legitimacy would gradually improve through public support for net-zero, and through promotion at events such as COP26.

Respondents to the spring 2023 survey highlighted the consideration of Engineering Biology (EB) as a key technology by UK Government and the increased discussion around EB across government

departments. One respondent pointed to a perceived greater awareness of IB and its association with a growing number of applications like food, dyes, lifestyle medication etc. However, one respondent believed that there continued to be a lack of understanding on the impact of IB, and that the benefits needed to be better communicated.

The autumn 2023 survey responses indicated continuing support and prominence of EB in government strategy and a greater drive to find more sustainable & environmental solutions using IB. However, some respondents pointed to a continued lack of IB understanding and the need for more and better communication around the benefits of IB.

Responses to the spring 2024 survey mirrored those from the autumn 2023 survey, with respondents highlighting the launch of the EB National Vision which has raised awareness of the sector across government. This was balanced with the views that awareness of IB benefits remains low. Some respondents questioned the importance of legitimacy to the consumer, who likely would focus on the attributes of a product rather than the method of its production.

5.5 Entrepreneurial Activity

We asked respondents to rate (1 to 5, with 1 being poor, and 5 being excellent) from their perspective "*how effective is the UK in stimulating and supporting entrepreneurial activity (start-ups, spinouts etc.) in industrial biotechnology?*". Although responses to the surveys showed a move from a slightly negative rating in the initial survey to a slightly positive rating, this reversed to a neutral rating in the latest survey.

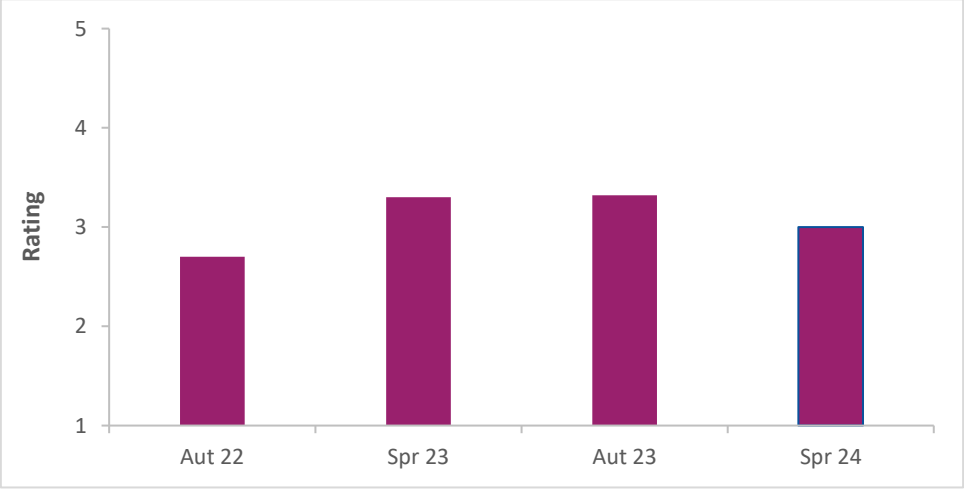


Figure 9: Rating of the support for entrepreneurial activity (shows a mean rating, with 1 being poor and 5 being excellent).

We asked respondents whether they feel that the "*entrepreneurial environment in industrial biotechnology is currently better, worse, or about the same compared to 12 months ago?*" The mean response to the last three surveys is that the entrepreneurial environment has remained the same, although some respondents have perceived an improvement and others believe that the environment has become worse.

Respondent Commentary

The spring 2023 survey highlighted that financial uncertainty and difficult economics had reduced the appetite for risk, with one respondent indicating that there was no entrepreneurial momentum in the UK at present. One respondent pointed to a perceived availability of funding for entrepreneurial activities, especially in "buzzword" areas, such as non-meat foods and carbon capture. Challenges (e.g., licensing terms, timeframes and equity demands) around spinning out companies from universities was also highlighted.

The autumn 2023 survey provided positive and negative opinions on the entrepreneurial environment. Some respondents pointed towards better training of PhDs to encourage entrepreneurial activities and an increased number of venture capital (VC) based Innovate UK calls, plus a greater engagement of IUK/Catapults with the VC market to support IB/EB. However, there was also a feeling of no real UK momentum and that there was more proactive support from outside of the UK. Difficulties in engaging with UK universities and the issue of IP was also cited.

Responses to the spring 2024 survey pointed to a challenging investment landscape and poor support for access to translation and scale-up infrastructure, and continued scarcity of patient capital. The iCure program was highlighted as positive endeavour in supporting entrepreneurial development.

5.6 Direction of Travel

We asked respondents to rate (1 to 5, with 1 being unclear and 5 being very clear) from their perspective, "*how clear is the direction of travel for UK innovation in their area of industrial biotechnology?*". From a relatively high degree of clarity in the initial survey the positivity of respondents reduced, but then climbed in subsequent surveys.

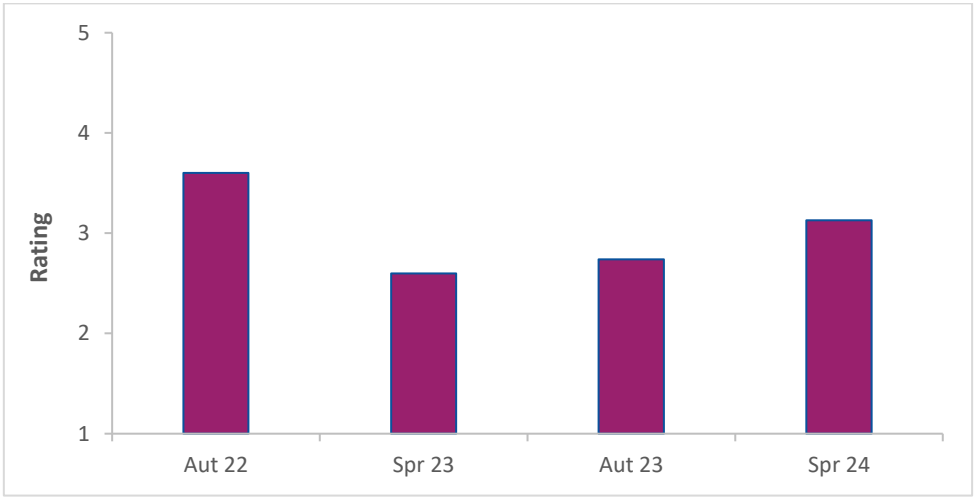


Figure 10. Rating the direction of travel for IB innovation (shows mean ratings, with 1 being unclear and 5 being very clear).

Respondents were asked "*whether the clarity of direction of travel (the innovation need and driver) is currently better, worse, or about the same compared to 12 months ago?*". The mean response (1=better, 2=about the same, 3=worse) to this question decreased from 2.46 in the initial survey to 1.69 in the latest survey, showing that respondents believe there is increasing support for industrial biotechnology and clarity around what can be achieved and what needs to be done.

Respondent Commentary

Multiple respondents to the autumn 2022 survey bemoaned the absence of a UK strategy for IB, with one respondent pointing to a lack of a desire to even have a strategic direction. Respondents pointed to a lack of industrial guidance and to retrograde government messaging on fossil fuels and the environment which has hindered development.

The responses to the spring 2023 survey indicated a frustration with multiple policies that are seen as aligned to IB, which is hindering progress. One respondent felt that the Government's post-Brexit innovation landscape was still uncertain and unclear. Other respondents were waiting for the publication of the bioeconomy strategy or were frustrated by changes to R&D tax credits, DEFRA decisions on compostables, and the position of compostables with the [single use] plastic [packaging] tax. One respondent pointed to the focus on engineering biology as a positive but believed that efforts were disjointed with a central champion and a more market focus required.

Opinions on the clarity of the direction of travel in the autumn 2023 survey were split, with equal numbers (seven) of respondents saying that clarity was worse and better compared to 12 months earlier, and a smaller number saying it was the same (five). Increasing activity in DSIT[3] around EB was considered positive while another respondent noted an increase in government funding. However other respondents commented on the ongoing lack of an IB strategy and pointed to an unhelpful Biomass Strategy.

Respondents to the spring 2024 survey pointed to an improvement in the clarity of direction due to the EB vision and roadmap giving much clearer national direction. However, some respondents felt that the UK lacked a cohesive strategy and that the government was weakening its stance on sustainability ahead of the 2024 general election.

5.7 Market Formation

We asked respondents, from their perspective, to rate (1 to 5, with 1 being hindered, and 5 being very supported) "*whether UK Government policies support market formation/development in their area of industrial biotechnology?*". Although the response to the first survey was positive, respondents to subsequent surveys provided negative ratings.

[3] Department for Science, Innovation & Technology

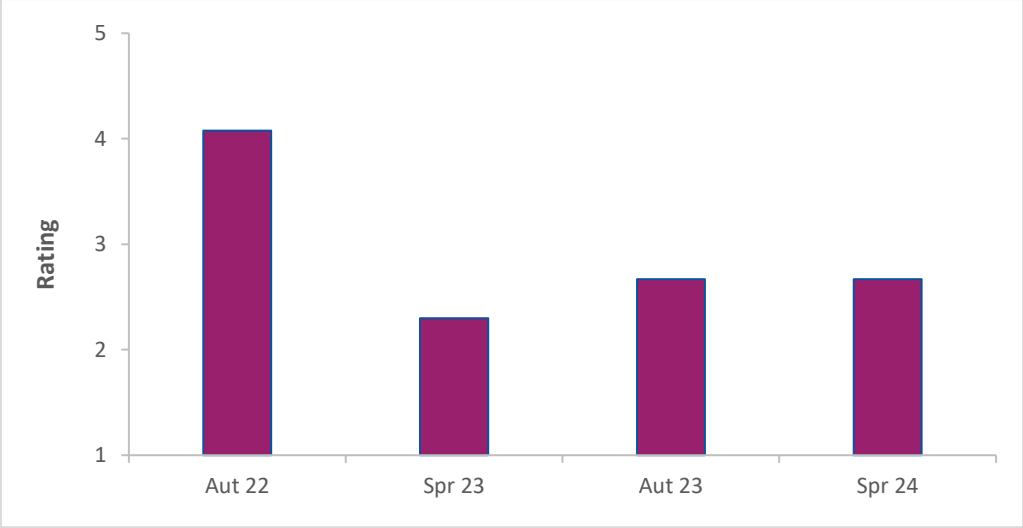


Figure 11. Rating of government support for market formation (shows a mean rating, with 1 being hindered and 5 being very supportive).

When asked whether "*the UK market development/growth is currently better, worse, or about the same compared to 12 months ago?*", the response had a mean result of 'about the same' across all surveys (scores remained between 2.23 and 2, where 1=better, 2=about the same and 3=worse).

Respondent Commentary

Respondents to the autumn 2022 survey pointed to government instability, retrograde messaging on fossil fuels and environment, and inflationary pressures as inhibiting the rate of market adoption of new technologies/products. One respondent suggested that various policy enactments have disincentivised IB. However, the prominence of net-zero and the easing of the economic crisis was seen as positive.

In the spring 2023 survey respondents again highlighted a lack of an Industrial Strategy and issues with a regulatory system diverging from large trading blocs. While one respondent indicated that funding to support innovation and consultations were helping (although slow and disjointed), another believed that there was no appetite for development of new products and associated regulations due to risk, cost and other barriers.

Many of the concerns expressed by respondents in previous surveys were also highlighted in the autumn 2023 survey. The impact of Brexit was still considered a major issue, coupled with the lack of an overall Industrial Strategy. A perception of government inactivity and an end-of-term paralysis around real action was indicated. Regulatory barriers were highlighted as major barrier to launching products in the UK. One respondent indicated that although on some specific issues like SAF there seemed to be [policy] movement, there was no movement specifically to support chemicals.

Respondents to the spring 2024 survey were equally spilt on whether market formation was being hindered or supported. Several respondents focused on regulation as an inhibitor to market formation, citing a lack of clarity on definitions and on the timeline of specific regulations, counterproductive taxation policies (e.g. Plastic Packaging Tax on compostables, biodegradables, and bio-plastics), a lack of clear regulation on labelling, and an unclear vision for the role of public procurement. It was also

noted that novel materials/foods regulation needs to be clearer. One respondent saw no evidence of strong government support for markets and believed that productivity in the agricultural sector is not considered a priority. On a positive note, one respondent cited recognition for EB and funding as being supportive of market formation.

6 Final Remarks

The barometer survey provides an indication of where respondents think the UK's innovation system is working well and where improvements need to be made. Within knowledge generation, fundamental research is considered to be performing well, whereas technology piloting and demonstration is considered an area in need of improvement. Respondents generally feel that knowledge exchange, direction of travel and, in particular, legitimacy are performing somewhat positively. In contrast, access to resources and market formation were seen as negatively performing areas.

Table 2: Summary of survey responses.

Innovation function	Performance Rating [4]	Perceived change in performance compared to 12 months ago [5]			
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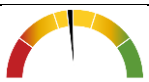
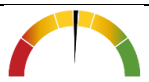
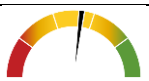
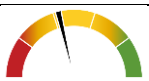
Resources		↓	↓	↓	↓
Legitimacy		↑	↑	↑	↑
Entrepreneurial activity		↓	→	→	→
Direction of travel		↓	↓	→	↑
Market formation		↓	↓	↓	→

[4] Based on a rating of 1-5 where 1 = poor and 5 = excellent: 

[5] Each arrow represents a survey (in chronological order). Arrows indicate the view of respondents (mean of responses). ↓ decrease in performance, → no change, ↑ improvement in performance.

NNFCC is a leading international consultancy with expertise on the conversion of biomass to bioenergy, biofuels and biobased products.

NNFCC, Biocentre,
York Science Park,
Innovation Way,
Heslington, York,
YO10 5NY.

Phone: +44 (0)1904 435182
Fax: +44 (0)1904 435345
E: enquiries@nnfcc.co.uk
Web: www.nnfcc.co.uk