City, Culture and Society 43 (2025) 100665

Contents lists available at ScienceDirect

City, Culture and Society

journal homepage: www.elsevier.com/locate/ccs

Transitioning from STEM to STEAM engagement mechanisms: a Yorkshire-based creative industry collaborative ecosystem approach for fashion and textiles

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ARTICLE INFO

Handling Editor: Prof Carl Grodach

Keywords:
Regional growth
Innovation
Creative industries clusters
Fashion & textiles
Triple helix

ABSTRACT

This paper adopts a reflective practice methodology, outlining how the Future Fashion Factory award stimulated sectoral activity, facilitating innovative collaborations and delivering regional impact. FFF built on decades of academic collaboration and long-standing relationships with both industry and local/regional government, it brought regional initiatives together to enable new activity and raise the profile of existing collaborations. In this context the University of Leeds, along with HEI partners, acted as a broker for innovation connectivity and change. It contrasts the Future Fashion Factory ecosystem with previous Yorkshire-based cluster programmes which had a STEM-based foundation for their interventions, reflecting differences in funding mechanisms and outcome monitoring. Fashion and textiles are a significant regional economic contributor, value chains are complex, integrating creativity with materials and advanced manufacturing requiring the delivery of STEAM-based interventions. Mills in the Yorkshire's 'textile heartland' are globally recognised, some exporting c.90 % of their total production. In January 2020 Future Fashion Factory supported the Massachusetts Institute of Technology Regional Entrepreneurship Acceleration Program (MIT REAP) visit, facilitating academic connectivity with Leeds City Council and a visit to AW Hainsworth & Sons Ltd; one of many collaborative initiatives. Over five-years Future Fashion Factory has worked extensively with regional and national bodies to maximise learning, impact and future opportunities. Since October 2018 it has developed and trialled several iterations of an industry-led Responsive R&D process. Focused on regional cluster support Future Fashion Factory recognised fashion and textiles as a national/international collection of complex, interlocking eco-systems. Future Fashion Factory network membership focused on regional connectivity but with UK-wide industrial participation; project awards always ensured direct cluster impact. Learning developed from this industry-led approach led to wide-ranging engagement activity and triggered c.450 innovation ideas and c.£47m co-investment.

1. Background

1.1. Yorkshire and the humber

This research discusses geographically based cluster activity within the UK region of 'Yorkshire and the Humber' (Y&H), unpacking University-Industry (U-I) innovative collaboration and the role of Higher Education Institutions (HEIs) as high-level intermediaries/brokers. It is set against the backdrop of ongoing discussion around the role that intermediaries, such as HEIs play within the Creative Industries Cluster Programme (CICP), could and indeed should take when considering triple-helix interactions and reconfiguration of system structure (Gilmore and Burnill-Maier, 2025; Bennett, 2020; Benghizo and Paris, 2016) through a discussion of Y&H-based initiatives. To place this location into a wider European geographical context Y&H is one of nine UK regions and has a population c.5.54 million (Clark, 2024); which makes it roughly equivalent to Norway or Finland in terms of population (Eurostat, 2023). Y&H contains c.270,000 active companies, possesses a diverse SME base and is home to nine universities. The region has four centres of governance; West Yorkshire Combined Authority (Fig. 1), South Yorkshire Mayoral Combined Authority, York and North Yorkshire Combined Authority and Hull and East Yorkshire.

However, comparing Y&H to other UK regions it received £788 million (5.4 %) of UK public-funded gross capital and non-capital R&D

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https://doi.org/10.1016/j.ccs.2025.100665
Received 22 January 2025; Received in revised form 18 September 2025; Accepted 19 September 2025
Available online 30 September 2025

expenditure, lower than the UK average of R&D expenditure (ONS, 2023), generates a little under 6.5 % of total UK turnover, and comes only 7th of the 9 English regions in terms of number of registered private-sector businesses which equates to 7 % of all UK registered businesses (Fig. 2). Comparing data from 2021 (GOV.UK, 2021) and 2024 the number of Y&H-located business decreased across the period. In terms of innovation activity Yorkshire appears to be punching below its weight, being home to ~8.2 % of UK population (Statista, 2024) and a significant HE infrastructure, so can be said to typify a less competitive/lagging region (Huggins and Johnston, 2009). A position that in terms of regional economic policy & government-funded development could reasonably be expected to be addressed via government investment (Rainton, 2012).

Despite the acknowledgement of Creative Industries within the sectoral research agenda (Bazalgette, 2017; UKRI, 2023a) the latest available data still has a focus on more traditional STEM-based areas of activity with the top industries, by number of SMEs, turnover and employment, being cited as 'Wholesale and Retail Trade: Repair of Motor Vehicles and Motorcycles', 'Construction' and 'Professional, Scientific and Technical Activities' showing that there is more yet to achieve before the creative sector achieves its full potential (Fig. 3).

However in terms of regional sectoral importance fashion and textiles (F&T) have been identified within Y&H strategy documents dating back to 2016 as significant for the region with clear identification of 'advanced textiles' 'engineering and textile businesses' and 'advanced textiles' and 'textile technology' within strategic plans and the focus of sector specific reports (Perspective Economics, 2021; WYCA, 2016). It should be noted however that key words used to identify the sector were more science-based and/or manufacturing focused. When the Creative Industries Cluster Programme (CICP) was proposed in 2017/18 it was apparent that Y&H provided an opportunity for the geographically co-located critical mass of historic textile manufacturers/associated business organisations (Fig. 4) to coalesce around a more inclusive agenda, focusing on the creative and digital rather than just manufacturing elements of the sector.

The research looks in detail at recent cluster activity funded through the CICP (UKRI, 2023b) with a lens on the Future Fashion Factory (FFF) Creative R&D Programme (CRDP) coordinated by the University of Leeds (FFF, 2022; Russell, 2018). This Creative Industry-focused activity reflects back on lessons learnt from previous Y&H cluster-based activity, namely the European Regional Development Fund (ERDF) supported Centres of Industrial Collaboration (CIC) programme (Innovation Partnership, 2024) focused on STEM-based sector activity, and Nanofactory, one of the CIC follow on programmes (Nanofactory, 2012; Williams, 2010). A sister CICP CRDP was also located within Y&H, XR Stories which focused on creatives working in the field of extended reality. This paper does not seek to unpack similarities and differences between the two Y&H place-based clusters, although it is noted that similar themes around cultural and innovation interventions can be drawn (Willment et al., 2025).

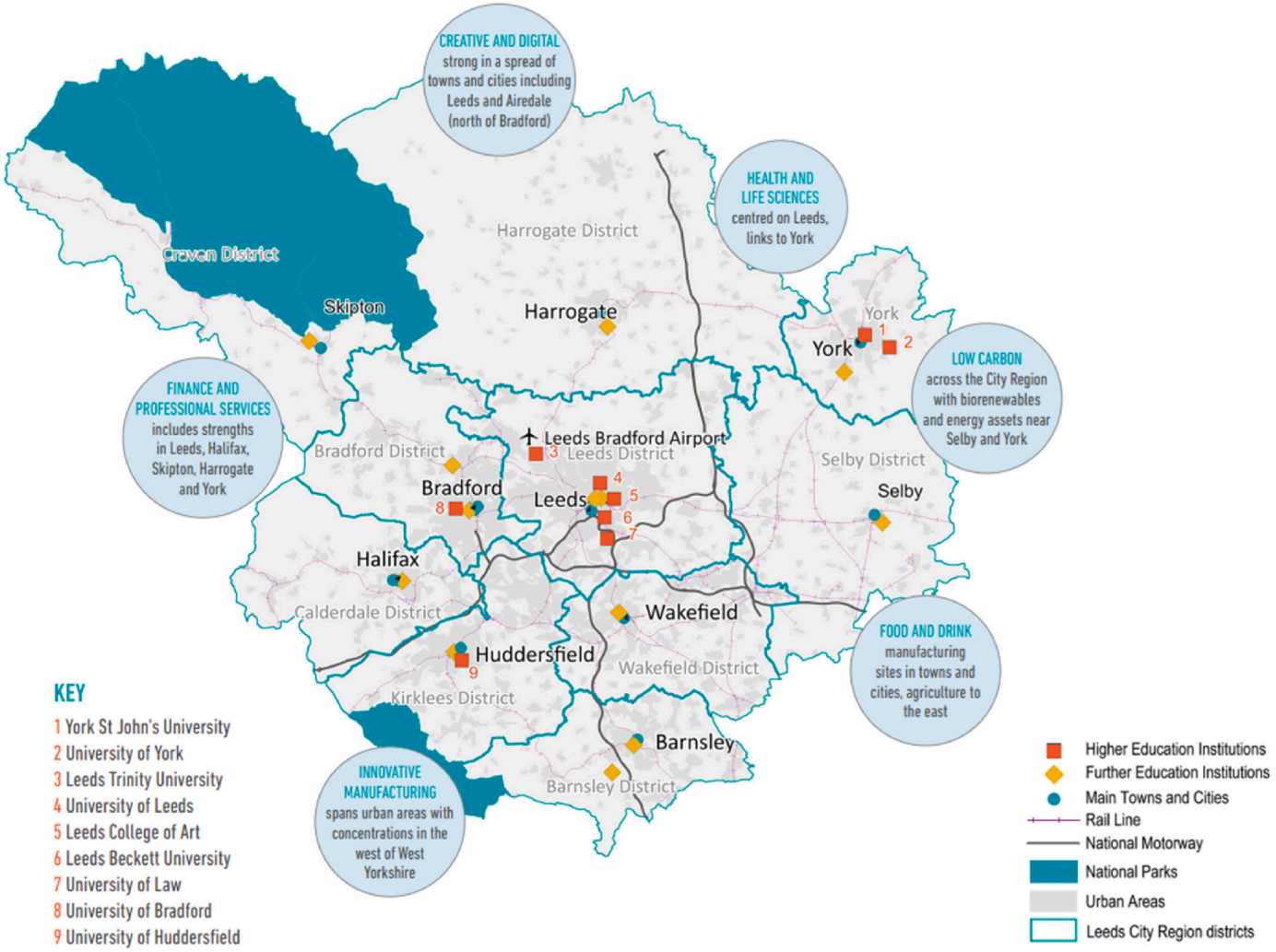

Fig. 1. Leeds city region: Places, Assets, opportunities and challenges (WYCA, 2016)(p.28).

Fig. 2. Estimated private sector businesses numbers in each English region, Scotland, Wales and Northern Ireland, start of 2024 (GOV.UK, 2024).

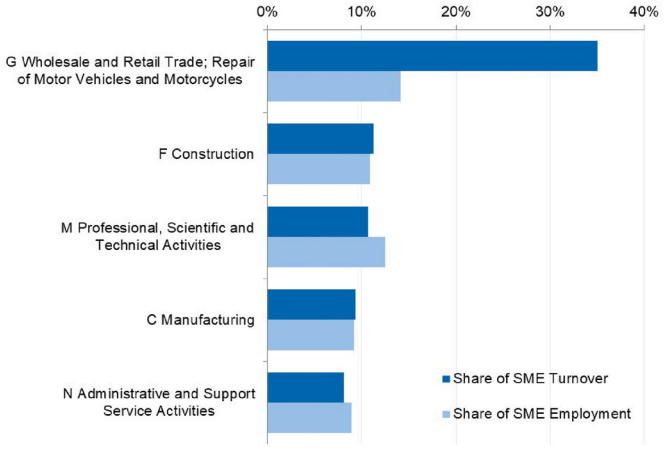

Fig. 3. Share of SME Turnover and Employment by sector (GOV.UK, 2024).

1.2. Future Fashion Factory

FFF as a programme of interventions reached across five core research themes, enabled >50 responsive mode project interventions (FFF, 2019), evaluated 464 innovation ideas and delivered 116 collaborative research projects. This research will not revisit any of these interventions in detail, there is previously published in these areas (i.e. (Almond, 2022; Almond and Rainton, 2025; AWH, 2020; Ellams and Postlethwaite, 2022; Hewitt et al., 2023; Teal et al., 2022)) rather here we look at the cluster mechanism.

In line with CICP gateway criteria FFF coalesced around the historic textile manufacturing hub of West Yorkshire, extended local supply chains within Y&H, and sector specific regional knowledge base present within the Universities of Leeds and Huddersfield. Whilst there had already been pockets of University-Industry (U-I) collaboration, in 2018 the cluster was developing rather than mature (Carbonara, 2004), a view which appears at odds with the well-established traditional nature of the sector. In this context we define U-I collaboration broadly, as the sharing of knowledge to effectively generate innovations. The additional elements of the definition usually brought out, a strategic aim to make positive commercial interventions and recognition of embedded innovative capacity, being the missing constructs which would have increased the maturity level of the then existing fashion and textile cluster (Dwyer et al., 2022). The perceived structure of existing Y&H relationships, more closed and competitive than collaborative amongst established manufacturers, and the reliance on quality of product and established client relationships made the concept of open innovation problematic. CICP funding changed this dynamic, enabling regional expertise to establish more significant connections with UK sector bodies (BFC, 2024; UKFT, 2024a), the offer of commissioned R&D funding providing an incentive for industry to engage, and the clarity of message around digital transformation a mission all consortium members could identify with (Williamson, 2019). Further concerns about succession planning, the need to both retain traditional skills and evolve business processes taking advantage of digital tools across extended supply chains, were added factors in cluster cohesion.

Sitting at the boundaries of STEM and STEAM F&T is certainly creative, in terms of having it's "origin in individual creativity, skill and talent" as well as the "potential for wealth and job creation through the generation and exploitation of intellectual property" (Crawford & Dewfield, 2022) however the very tangible nature of F&T outputs coupled with a long history of STEM innovation/textile engineering have been reflected in skills provision which has a tendency to split fashion design activity from manufacturing based skills (FFF, 2024a). A further consideration around comparatively low levels of digital readiness (HMRC, 2024) brought additional challenges to U-I engagement, this element of skills development being a focus for both UKFT and the

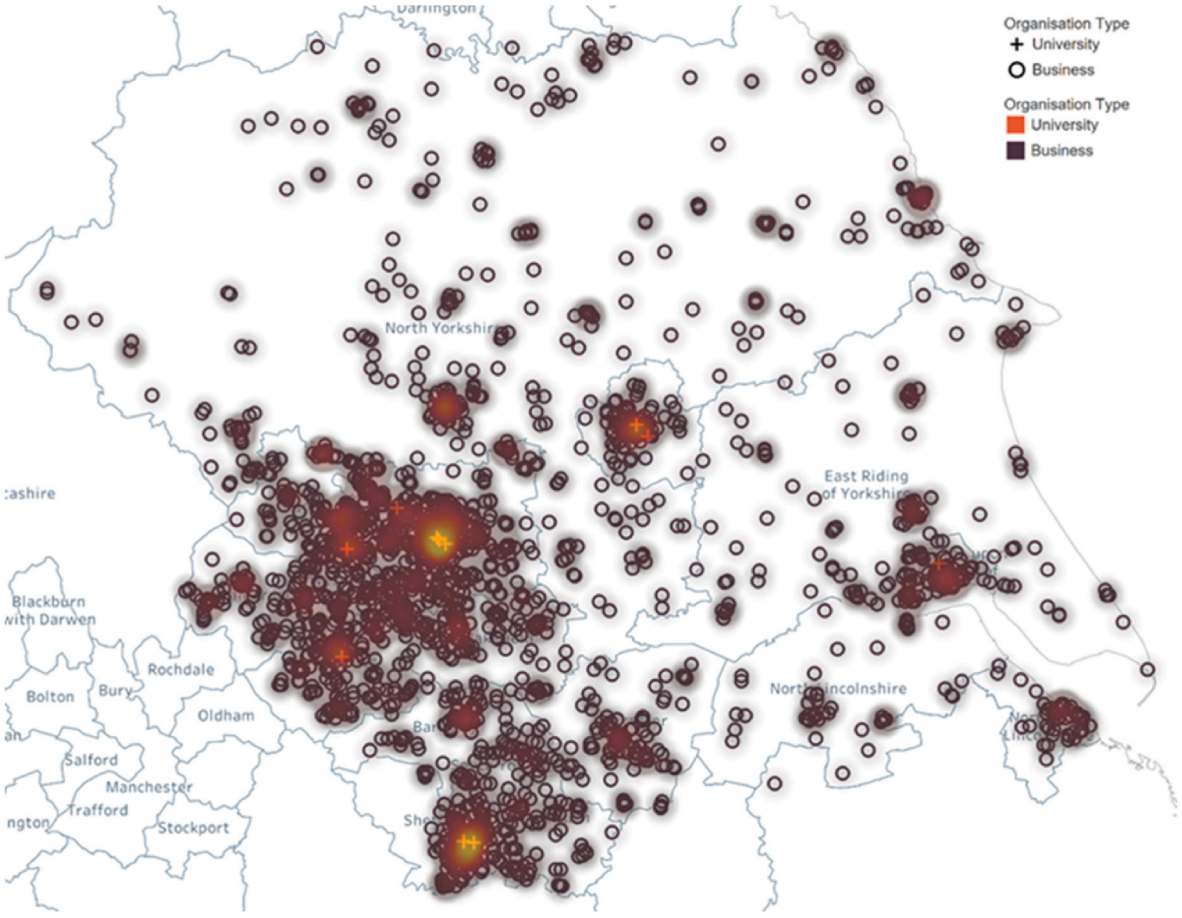

Fig. 4. Ref: Perspective economics, fashion & textile in Yorkshire (Perspective Economics, 2021).

Textile Centre of Excellence (TCoE) (TCoE, 2023) throughout FFF programme delivery. This element of digital supply chain integration was spotlighted during the COVID 2019 period, funding calls during that period (2020–21) generating a range of Responsive R&D projects and important impact information. The acceptance of the whole F&T supply chain as a creative industry was a very important factor for FFF within the CICP application process, explicitly bringing out design elements being critical to supply chain cohesion and making holistic impact more visible.

1.3. Aims and objectives

The research explores how Y&H-based cluster mechanisms have transitioned from STEM-based transactional activity to STEAM-based whole ecosystem impact focused co-development.

- ❖ To demonstrate the FFF CRDP as a creative industries cluster case study, detailing a maturing ecosystem within a geographic area previously focused on STEM-based innovation activity.
- ❖ To unpack how specific ecosystem interactions facilitated engagement, learning lessons around stakeholder influence and ecosystem co-development & integration with a focus on the role of the academic institutions.

2. Materials and methods

2.1. Literature review

When providing an overview of the literature against which to position FFF, and previous cluster activity within Y&H of relevance to this research, we consider fields relating to the operational management/development of collaborative clusters (trust, empowerment, impact, co-opetition), cluster mechanisms (triple-helix, university-industry collaboration, funding strategies) and sectoral focus (STEM, Creative Industries). Added to this the specific areas relating to the type of industrial cluster activity targeted (SMEs, high growth potential) and the creative industries which are the focus of the CICP intervention.

2.1.1. Cluster-focused regional mechanisms: triple-helix

More recent CICP programme and previous European Regional Development Fund (ERDF) & Regional Development Agency (RDA) funded interventions (YF, 2006) sit firmly within a regional context, being constrained by funding to focus on U-I interactions within Y&H; all targeted a regional industry-base and outputs are linked to interventions which target regional growth. These interventions can be considered as: (1) a series of interlinked innovation networks, sector or technology specific and based on the specialism of individual intervention involved (2) in the case of the CICP, a series of 'stand-alone' regional innovation networks, looking at the programme as a whole & the research-intensive universities represented within it, and (3) looking at FFF, the CICs and Nanofactory, part of a wider regional system that is encouraging Y&H to move towards becoming a self-sustaining 'knowledge-based region' (Etzkowitz and Klofsten, 2005).

To enable exploration of these interventions the concept of a Triple-Helix System can usefully be adopted; discussed within the literature since the late-1990s it is still a developing area of research. Leydesdorff & Meyer, in their introduction to the special issue of Research Policy, provide a clear framework for considering the interactions of the three players in this system: industry (wealth generation), academia (novelty production) and government (public control) (Leydesdorff and Meyer,

2006) however CICP delivery has highlighted that these strict definitions are more shades of grey than black and white in practice with an understanding that co-development of 'novelty production' is a more impactful instrument. Additionally, Leydesdorff & Meyer make the point that "when one focuses on university-industry relations, the addition of the dimension of government raises issues like the systematic evaluation of these relations". In the case of the CIC programme and Nanofactory the 'government' dimension was provided by the ERDF/RDA public-sector funding support for the programme, and for the CICP it was the Arts and Humanities Research Council (AHRC) (UKRI, 2024c) and the Industrial Strategy Challenge Fund (ISCF) (IUK, 2024; UKRI, 2017), which in turn is driven by aspirations articulated within national and regional policy frameworks. Whilst there is a reasonable body of literature discussing the policy implications of various influencing factors there is a scarcity of publications dealing directly with the actual intervention mechanisms used by 'government' to influence practice & whether they work. As the programme of interventions studied here is very clearly influenced by its funding then there is scope to consider whether a particular mechanism, which in turn influences the development of intervention delivery mechanisms is 'fit for purpose' in the context under discussion.

Three potential sources of variation within a triple-helix system have been identified: (1) differences of industry sectors, reactivity in relation to technologies that are relevant to them (2) take-up of different technologies, different platform technologies introducing different patterns of innovation and diffusion and (3) national systems of innovation (government-led), resulting in differences in integration/differentiation of the three actors in the innovation process ((Leydesdorff and Meyer, 2006) after (Etzkowitz and Leydesdorff, 1995)) all of which are relevant in this context. These differences in national policy systems have been shown (Boldrini et al., 2011; Roper, 1997) to have a significant impact on effectiveness of triple-helix interventions. By providing insight into a regional innovation system, interventions affected by differing policy structures, including a range of HEI players and individual platform technologies/industry sectors, this study provides insight within a regional environment (Y&H) and the interfaces between these three sources of variation. A useful way of visualising the triple-helix system is provided by Leydesdoff & Meyer (Fig. 5), although the indicative output used (patents) has its drawbacks as an indicator of the success of the system, specifically in the case of the creative industries where patents are not the paramount protection mechanism.

A range of indicators & methodologies have been used to try and quantify the impact of government-industry-academia working together; variously these include, for example: company formation, university 'spin-outs', job creation and/or retention, authorship of research articles and patenting activity. The complexity of the triple-helix system however, the number of external variables, not least in terms of target sector (Leydesdorff and Meyer, 2006), and the myriad of ways in which they can react one with the other, means that "one cannot expect a Triple-Helix to become stable and therefore observable". Etzkowitz & Klofsten acknowledge within their 2005 paper that "each regional development project is a unique instance" but the authors believe that their model defining four stages of development can identify some general elements such as the "triple-helix and the entrepreneurial university" which is very relevant here (Etzkowitz and Klofsten, 2005). It is unclear however whether their data related to different industrial sectors and/or different platform technologies so it appears conclusions are being drawn from a 'whole region' approach. Rather the observable variation can be considered as providing "mutual information between the systems" (Leydesdorff and Meyer, 2006) which can then be used to inform evolutionary modelling. Here we bring out the progression of these modelling methodologies from the transactional to the holistic as they vary from STEM (CICs & Nanofactory) to STEAM (CICPs) interventions.

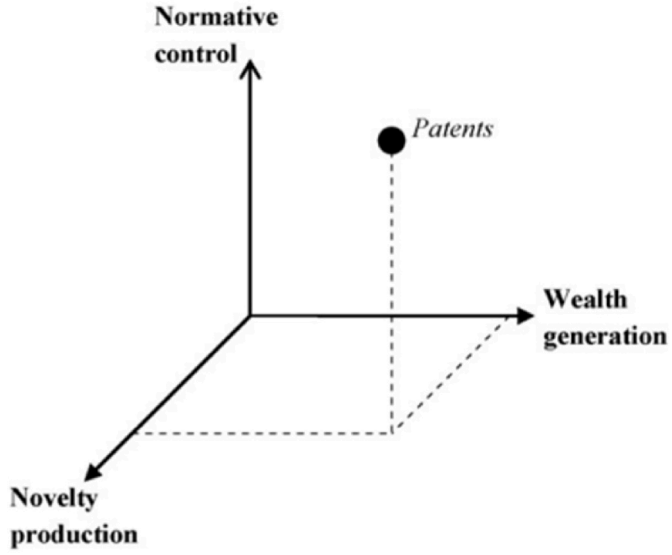

Fig. 5. An analytical scheme for studying the Triple-Helix as a neo-evolutionary model (Leydesdorff and Meyer, 2006)(p.1443).

2.1.2. *SME learning, regional context*

Previous Y&H-focused studies found that SMEs "tend to utilise and value more knowledge contact networks with actors outside the region" and "more innovative SMEs possess a balance of inside and outside the region knowledge networks" (Huggins and Johnston, 2009) which does make one question the effectiveness of regionally-bounded funding. Petruzelli also questions the importance of geography finding that, at least for exemplar innovative universities, geographic proximity should not be considered a constraint (Petruzzelli, 2011), his recommendation that "policies to promote collaboration [should] be more akin to a "match-making'' service than creating a local bazaar" again goes against accepted regional policy wisdom. Huggins concludes his paper with the statement that "regional public policy makers need to renew their efforts to support SMEs in creating and sustaining their knowledge networks" as it is these networks that support SMEs to become more competitive. This support element becomes even more imperative when you consider that the "increasing attention to the management of U-I links through government policy efforts" and indeed the increased HEI admin burdens (Bruneel et al., 2010) which go hand-in-hand with these efforts will have a tendency to increase, rather than decrease, associated transactional-barriers; not what was intended by policy-initiators. Whilst there is some support for the premise that nurturing regional networks and clusters, even in this time of inter-connected global markets, is positive and will encourage resources to "flow to the more attractive regions" thus created (Ketels et al., 2008) there is a strong current of scepticism running through the literature. In addition to reservations expressed about geographically-bounded policy there are concerns about motivations behind achieving funder outcomes and "an inference that emergent high technology business development ….may lack commercial realism due to the level of Government (RDA) support" which could "lead to non-viable spin outs and discrediting of the University Technology Transfer agenda" (McAdam et al., 2012). Additionally Fiore notes that "In the design and/or the implementation of regional innovation policies, the role of "intermediary agencies" … … helping to define a shared vision and acting as a co-ordinating body is crucial" (Fiore et al., 2011). Likewise, Pratt (Pratt, 2021) explores the definition of creative hubs, by way of history, place and with a focus on supporting user needs, all of which factors were present across the CICP networks and facilitated by the academic collaborators. In the FFF intervention one could argue that this co-ordinating role was larger than the HEI network, relying heavily on sector body engagement and dissemination activity to accelerate momentum. Yet the continuation of these co-ordinating bodies, necessary to support development of

long-term collaborations, is dependent on public-sector funding which tends to be cyclical in nature. The development of these new dependencies driven by public sector support of U-I collaboration moreover is inconsistent with longer-term UK government policy goals. Studying EU & US collaborations Archibugi (Archibugi and Coco, 2004) found a worrying lack of connection between European academia and industry, with European businesses showing a preference to collaborate with US-located research institutions over more geographically convenient European counter-parts. His statement, that "European academia is becoming more and more isolated from business", is in direct opposition to the aims of EU R&D policy, and the conclusion that EU policy has "still not been able to make Europe a junction of technological exchange" a reflection of the limitations that exist within all EU funds (in this case ERDF) targeted towards stimulating a 'step-change' to embed an EU-wide innovation culture. Looking in more detail at what works for SMEs Robson & Bennett find that "the private sector provides the chief relationship of use of external advice and increases SME performance" (Robson and Bennett, 2000) whilst publicly-funded sources are less relevant, or impact negatively. Their statement that "the lack of positive relation of firm performance with the use of any government-backed agency should be a strong warning to new policy initiatives" continues to be very relevant. Fiore's findings, that whilst "the capacity to innovate and to assimilate innovation is a key factor to improve the economic dynamism of any territory" and there is "a broad consensus on this concept, the link between research, innovation and economic growth appears less clear" (Fiore et al., 2011), again appears to question over-reliance on triple-helix concepts to stimulate a vibrant regional economy. Further findings suggest that SMEs are more likely to engage with state-funded/promoted networks when they are under pressure, to help arrest decline (Robson and Bennett, 2000), therefore can one postulate that structural funding is only really viable in times of economic downturn? It was certainly true in the case of FFF that rather than a downturn in Responsive R&D applications during the COVID lockdown, a significant stressor during CICP delivery, there was greater interest expressed in the Responsive R&D funding mechanism.

2.2. Methodology

This paper adopted a reflective practice methodology (Schon, 1983), drawing out differences in focus, mechanisms and delivery between STEM and STEAM (Independent, 2016) cluster interventions. The method was deemed appropriate as the lead author was actively involved in various roles covering the monitoring, development and running of the interventions reviewed, a strong position from which to reflect on the research activities involved and impacts delivered. This approach enabled the researcher to critically analyse the contracted outcomes across Y&H-located interventions in terms of funder approach, target sector and using a lens which enabled comparison of STEM vs STEAM focused outcome monitoring. Through both reflexive and contemplative analysis, the results of the practice permit progressive insight related to its impact (Colwell, 2024; IoDS, 2024; Scaife, 2010).

Reflective practice was adopted to consider the Y&H contracted outcomes in terms of quantitative outputs and developed mechanisms/relationships within each funded intervention; mapped against funding source, targeted cluster, and policy drivers. The objective was to identify how the different interventions generated new knowledge, underpinning the reported outcomes, and how this provided tangible impacts for Y&H. The methods used to collect data throughout the projects were varied. Project and programme reporting was analysed alongside minutes from management meetings, evaluation feedback, personal reflections around effectiveness of mechanisms used; both qualitative and quantitative elements were interrogated. Reflections around stakeholder feelings of empowerment and trust were drawn out from management activity and Responsive R&D evaluation processes. George characterised this approach commenting that mixed methods enable " … a more complete picture than a standalone quantitative or qualitative study, as it integrates benefits of both methods'' (George, 2022). Patterns of activity, responses to interventions and concept development were unpacked through systematic analysis of programme content (Hassan, 2024). Content analysis was kept at a strategic programme level, intervention definition and recording as a reflection of funder requirements and priorities for substantive outcomes. Micro-level impacts (i.e. Responsive R&D projects in the case of FFF and individual innovation grants in the case of Nanofactory) are the subject of other publications and so not analysed within this research.

2.2.1. Background to Y&H cluster interventions

The CICP programme is not Y&H's first experience with sector and cluster thinking. In 2006 Yorkshire Forward, the then Regional Development Agency, delivered two multi-million pound umbrella schemes of funding: Cluster Development Scheme (CDS) and the Business Support Scheme (BSS) utilising the European Regional Development Fund (ERDF) regional competitive and employment programme (YF, 2006). This programme resulted in several focused cluster interventions within Y&H of which we discuss here the CIC and Nanofactory programmes. The author has personal experience with both, being the ERDF monitoring officer for the CICs, the Nanofactory Programme Manager, and the FFF Programme Manager. The reflective practice learning approach (Colwell, 2024; IoDS, 2024; Scaife, 2010) utilised, has been made possible by the author's roles within each of the interventions being discussed, with a view to gaining insight by comparing and contrasting the different delivery and monitoring mechanisms in use. Each of the regional interventions developed their own approaches relevant to specific sectoral targets but the similarities in delivery are wide ranging, with sector body facilitation and engagement/dissemination mechanisms being developed in each case.

The CIC programme provided a publicly funded mechanism that was designed to kick start a more commercial level of engagement between Y&H's research-intensive universities and regional business community. Key to this approach was the assumption that the industrial engagement process would be led by experienced Commercial Managers, selected mainly from industry not academia. This engagement was targeted at areas of 'excellence' in mainly emerging technologies within the supported universities. University partners included a range of organisations from Russell Group (Russell Group, 2025) members to post-1992 (Read, 2024) institutions. All CIC interventions were STEM led, except for the Digital Printing CIC although even in that case the focus was on manufacturing-based rather than creative innovation. The role of the academic partner within these interventions was very much as a disseminator of knowledge/skills, academia as a knowledge base and possessor of innovation infrastructure which industry should wish to utilise. The explicit aspiration for the CIC Commercial Managers to have an industrial background was framed as a way to leverage industrial experience to rapidly develop academic-industry innovation networks. The CICs as an exemplar of the type of science-based cluster initiative; selected through a competitive process in order to access government financing; theoretically represented a high performing system (Ketels et al., 2008) which should have provided clear evidence of the effectiveness, or otherwise, of this type of intervention. The Nanofactory Programme (2008–2014) can be seen in the light of an extension of the CIC methodology, bringing together elements from several industry sectors with a broad ranging focus on micro-nano capability to support cross-sectoral innovation. Still ERDF funded the Nanofactory programme worked to the same range of contracted outcomes but developed an additional strand of activity, building R&D grants, to encourage stakeholder engagement (Kelly & Rainton, 2010, May-2010).

3. Findings

Comparing and contrasting CICP funding, derived from UK government sources (AHRC/ISCF) and previous cluster initiatives which were

funded by European structural fund interventions (DCLG, 2013), it is possible to note a progressive shift in approach. Major changes in innovation cluster thinking are apparent within the contracted research outcomes built into each programme of interventions and how these in turn influenced the structure and mechanisms of funded projects. The Y&H-based European funded programmes mentioned here contracted on a linear investment model, operating on the premise that if you put funding in at one end then you were effectively buying tangible and quantifiable outputs which came out of the other end (Fig. 6). This ERDF reporting was reliant on defined outputs; SME Assists, jobs created, jobs retained, number of R&D projects, patents filed, businesses created; with little allowance for more qualitative evidence around ecosystem evolution or case studies allowed for within formal report formats which were centred around evidencing financial defrayal. The concept of providing support to an SME; via an 'SME Assist'; itself was more about evidencing that a specific amount of time had been spent with the business in question rather than what had been achieved and subsequent activity.

This format encouraged academic institutions to develop mechanisms focused on industrial engagement via a beauty parade of what they had to offer, the Commercial Manager role being effectively a salesperson facilitating access to infrastructure and academic expertise. To support this engagement model CIC funding was crafted to provide a significant amount of promotional engagement budget, dedicated to attendance at tradeshows and production of marketing collateral, a fixed budget line which in practice it was challenging to spend. A commonly recurring comment from interviews suggested that the combination of high marketing spend and time-bound rather than outcome-focused reporting around SME support was unhelpful. The ability to build capability within SMEs to engage with wider innovation funding programmes was not present or fell outside the CIC project remit and the tick-box approach to 'SME Assists', the mantra being "the more the merrier" to meet regional and national reporting targets, counter-productive to meaningful long-term engagement.

The Nanofactory programme, which contracted after the CICs and incorporated learning from those interventions, sought to address this issue as much as possible whilst still being bound by ERDF output focused reporting. A new 'building R&D grants' approach was included within programme budgets enabling the employment of a Business Development Manager dedicated to identifying additional funding opportunities and supporting external bid writing activity. As a result reporting against R&D projects delivered targets was expanded to include activity not directly funded by the grant, and assistance provided to Y&H-based SMEs supported upskilling staff on funding mechanisms and also went someway to improving absorptive capacity (Cohen & Levinthal, 1990; Lu, 2023; OR, 2025) via targeted outcome planning.

Looking to the CICP intervention, the AHRC/ISCF mechanism generated what could be described as a cluster of clusters. Using Porter's definition of a cluster "geographic concentrations of interconnected companies, specialised suppliers, service providers, firms in related industries, and associated institutions" (Porter, 2000) this can be seen to be true at the individual CRDP level, but also at the macro level, the whole CICP programme being designed to promote inter-CRDP collaboration across the UK macro cluster of creative industries level. The CICP programme mechanism contrasts sharply with the linear/quantitative approach within the ERDF-funded STEM programmes described above. Whilst inevitably requiring formal reporting against contracted Key Performance Indicators (KPIs) the creative industry approach enabled individual CRDP applicants to select from a range of outcome indicators within their initial application. These were then brought together in a benefit mapping approach (Table 1) which was co-designed, facilitated by an external agency consulting with the CRDPs, and evolving across the delivery period. Whilst quite cumbersome to develop and apply, particularly at points where reporting templates varied with feedback, this process facilitated a more nuanced approach to programme reporting. Benefit mapping enabled a more qualitative approach, alongside the KPI figures, and the funder approach encouraged submission of case studies and report narrative. This in turn we would argue removed the focus from purely output driven quantitative mechanisms and facilitated a move to a more rounded ecosystem outcome focused methodology. In this context we use the term outputs as primarily short-term, process-based findings achieved due to application of specific policies/actions whilst the term outcomes represents longer-term systemic behaviour change (i.e. after (Abbott et al., 1998; Montague, 2000; Schalock and Bonham, 2003)).

Reflecting on elements of FFF programme delivery across the period one can point to the joint local authority-academic-industry engagement from the early phase of FFF MIT visit (Leeds City Region LEP, 2020) all the way through to current activity with Climate Action Leeds (Rawsthorne et al., 2022) and the Leeds Doughnut approach to mapping F&T impacts. The MIT REAP visit, coordinated between Leeds City Council and the University of Leeds with local industry engagement and hosting of activities, provides early evidence of international recognition for the developing F&T cluster and is an exemplar of triple helix partnership in action. Analysis of progressive management meeting minutes demonstrates increasing levels of trust and willingness of industry to engage in project activity, with public confidence in the cluster approach being expressed within the Spring EXPO event in 2024 (Almond and Rainton, 2025; FFF, 2024b). Looking across FFF programme output reporting KPI evidence points to an increasing awareness of the benefits of collaboration to address strategic challenges, i.e. the number of large-scale collaborative funding submissions at 294 % of

Table 1
CICP Key Benefits - developed from evaluation themes (BOP Consulting, 2020).

	Outcome focused, benefit definition
Benefit 1	Creation of an environment for new and experimental creative content, products, services and experiences
Benefit 2	Generation of long-term strategic, applied research partnerships and creative enterprises for Higher Education Institutes and other relevant sectoral and local stakeholders
Benefit 3	Improvement of creative and digital enterprises' ability to access the skills, knowledge and expertise they require to develop new products and services
Benefit 4	Key place-based/sector issues are addressed through applied research programmes
Benefit 5	Economic and social benefits are generated (including co-investment)

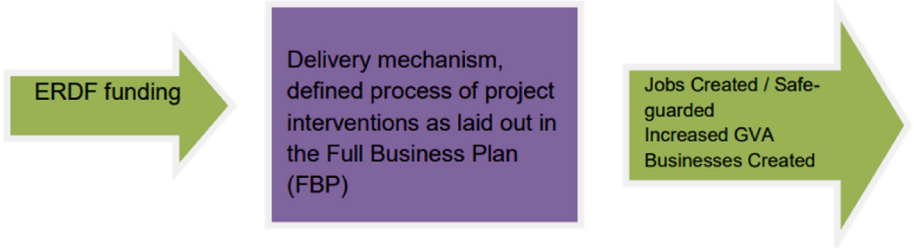

Fig. 6. Simplified CIC investment/outcomes (Rainton, 2012).

original target reported, and KPI outputs do come together to evidence a maturing ecosystem (FFF, 2025).

Porter also thinks about clusters of "fields that compete but also cooperate" (Porter, 2000). There is evidence from FFF that part of the academic role, convening and brokering of mechanisms to enable strategic sectoral discussions at a pre-competitive level, not only encouraged industrial engagement in individual academic-industry projects (i.e. via the Responsive R&D mechanism) but also broke down barriers to engagement in larger collaboration research programmes. Explicit engagement of sector bodies added to the CRDP's trust dynamic, as did leveraging of long-standing individual academic relationships with members of the industrial network. Willingness to engage in subsequent collaborative programmes (LITAC, 2024) and the co-petitive relationships (Gnyawali & Park, 2011) forged during collaborative programmes such as the UKFT-led Fashion Trust (UKFT, 2021) further demonstrate this point. Learning and recommendations for future F&T investment, building on delivery practice across both F&T CRDPs (Rainton et al., 2025) reflect on the importance of providing funding opportunities for collaborative mechanisms which involve multiple players who together can affect systemic change.

Looking more widely at the whole CICP network, embedded thinking has a stimulated an important shift in attitude towards collaborative rather than competitive funding awards across the initial nine clusters. A number of examples exist of inter-cluster pollination such as fashion and games, in the form of the Interactive Sustainable Fashion Challenge, a collaboration between FFF and InGAME (FFF, 2023), and XR Network+, a collaboration including five of the nine CRDPs (XRStories, 2025). Of significance for F&T is the Fashion Demonstrator, additional funding provided by AHRC and DCMS which was awarded dependent on collaboration between the two fashion and textile focused CICPs; FFF and the Business of Fashion, Textiles and Technology (BFTT) (UAL, 2024); to deliver outcomes for the UK sector. At the time of writing this cross-cluster collaboration has already published three reports (Connor-Crabb et al., 2025; Hemingray et al, 2023; Rainton et al., 2025) with the fourth in this series due to be published imminently. This financial, and policy influencing, mechanism incentivised collaboration, an approach which has continued within the current Plus in Circular Fashion and Textiles (UKRI, 2023c) whereby three subnetworks (FFN+, 2024; IMPACT+, 2024; LITAC, 2024) have been supported by a trilateral consortia of funders. Overall a £15 million programme of tailored interventions has been developed between AHRC (UKRI, 2024c), NERC (UKRI, 2024b) and Innovate UK (UKRI, 2024a) which brings together a wide range of academic and industry partners in collaborative impact focused research (CFIN, 2024; UKFT, 2024b) that fully integrates the voice of industry. Inclusive contracting mechanisms have been defined by one subnetwork which acknowledge the importance of sectoral bodies such as UKFT and WRAP/Textiles 2030; (WRAP, 2023) within the maturing ecosystem. The Network Plus for Circular Fashion and Textiles explicitly leverages existing CICP F&T connectivity, extending the reach to include additional academic and industry partners and continuing the academic role in the expanding ecosystem as both activity broker and secondary funding body. The brokerage role of academic institutions within this ecosystem model being of particular relevance and speaking to Bruneel's comment regarding the need for support to mitigate transactional barriers; a Y&H finding running throughout both STEM and STEAM interventions.

4. Discussion

Many countries/territories have had policy statements in place for several decades, highlighting the importance of different forms of collaboration, knowledge transfer/exchange between research organisations/HEIs and industry, and in the main it is fair to say that at least initially there was a focus on technical innovation which lead to tangible outcomes (i.e. (EURACTIV, 2011; European Commission, 2006; OSTP, 2014; TSB, 2008)). Focusing in on the UK, included within the remit of UK Research and Innovation (UKRI) (UKRI, 2025) are initiatives such as Knowledge Transfer Partnerships (KTPs) (IUK, 2025a) and Innovate UK Business Connect (previously Knowledge Transfer Networks (KTNs)) (IUK, 2025b), each targeting activity across a specific research/-industrial community. Together such government-led initiatives shape the necessary environment providing support for "appropriate R&D activities" and promoting "network formation among actors for collaboration" (Choi et al., 2011). Freel, writing in 2003, noted that the prevalent view of firms as "being seldom capable of innovating independently and never in a vacuum" has "considerably influenced European industrial policy" and driven "UK competitiveness policy throughout the 1990s" (Freel, 2003) which continues to be largely the case to the present day.

Looking to the literature several papers make mention of programmes of public-funding that influence the phenomena they describe (eg (Archibugi and Coco, 2004; Bjerregaard, 2010; Luukkonen, 1998):) but there tends to be no detail present beyond this brief mention, certainly no detail on why specific funding mechanisms are used or how they impact operationalisation of the process. Yet it is this very level of detail that has been identified as crucial to understanding how the whole system contributes to the desired outcome of regional innovation and wealth generation. Examples of this type of skirting around the operational 'government' angle of the triple-helix system are provided by Bjerregaard; qualitative approach to discuss institutional and cultural aspects of U-I collaboration but only mentions the EU research and innovation processes in passing in the introduction (Bjerregaard, 2010); Heinze; qualitative methods to look at public research systems in Germany (Heinze & Kuhlmann, 2008) by way of publications and patent applications, mentions that "research collaboration is facilitated when partners have sufficient core funding" but doesn't then go on to discuss specifics of the "third party funding" driving collaborations; and Huggins, using a quantitative approach to studying this region (Y&H) mentions only in passing that the region has benefitted from "restructuring grants from the European Union" (Huggins and Johnston, 2009). Policy rhetoric around 'working together for the common good' is therefore prevalent but has been relatively unsupported in the literature. And amongst this discussion the exact role of the academic portion of the triple-helix is somewhat obscure.

It must be remembered that different stakeholders have their own agendas which may not be all that altruistic and so not fully supportive of a triple-helix approach. As Robson states "whilst government may desire employment growth to achieve political aims, this is not necessarily convergent with SME goals" (Robson and Bennett, 2000) which may be more focused on job cuts to save costs. Equally academic partners have their own drivers, which can sometimes be at odds with those of both the government and industry portions of the triple-helix, although programmes of government interventions are increasingly designed to ensure that at least academia and policy are working hand in hand. The post-funding longer-term commercial impact of interventions as a main indicator of success however, the industry element, is still somewhat problematic with the cyclical nature of innovation funding (typically 3 to 5-year cycles) not being conducive to sustaining reporting mechanisms past project end dates. The argument that policy interventions need to strengthen research both at universities and the corporate sector (Leydesdorff and Meyer, 2006) if innovation clusters are to maximise performance and impact is valid, however such policy-focused funding also needs to take account of the need for sustained effort & longevity of innovation mechanisms if trust in maturing ecosystems is to be maintained.

In the case of Y&H government funded interventions clearly mirrored the general global approach. The CICs were chosen using technology-based sector assessments and the programmes of European funding which supported both the CICs and Nanofactory clearly focused on tangible outputs. Possibly a failing of early structural fund interventions was the need for explicit clarity across Member States which focused evaluation mechanisms into the use of quantitative KPI output

reporting. The UK-funded CICP programme had no such imperative so had more freedom to explore more qualitative outcomes. The pros and cons of structuring CICP evaluation in this way encouraged mechanisms involving an explicit and carefully orchestrated strategic blend of skills sets (within the programme delivery team), business interests (regional and UK-wide networks) and stakeholder connectivity (convening management systems which combined industry-academia-policy makers). Taking CRPD outcomes as evidence, this approach can be seen to have nurtured deepening levels of trust across ecosystem relationships and shifted stakeholder boundaries. Interviews, both from internal case studies and evaluation processes, point to a significant shift in perception of the role of universities from industrial ecosystem partners as a result. A deliberate funder strategy, to continue to monitor and nurture relationships post-funding via strategic liaison and on-going event attendance, can be seen to be moving individual CRDPs from short-term projects to semi-permanent constructs which can be revisited for input into co-development of future strategy instruments. Etzkowitz and Klofsten do make the statement that "relatively few regions have exhibited self-renewing capabilities" (Etzkowitz and Klofsten, 2005), the implication being that practice has yet to operationalise theory, however the holistic ecosystem approach engendered by the CICP intervention does appear to be bearing fruit.

5. Recommendations

We see this research feeding into the policy review recommendations for UK circular fashion and textiles, providing an evidentiary element to support place-based sectoral cluster focused triple-helix activity for the sector. During delivery (October 2018 to May 2024) FFF has proved a mechanism comprising several strands of activity, co-designed collaborative interventions focused to strengthen U-I relationships for the fashion and textile sector. Whilst starting from a geographic cluster perspective FFF has become established as an innovation broker across the UK and through its delivery mechanism forged closer working relationships with the UK Fashion and Textile Association (UKFT, 2024a) and funding bodies. It also provides evidence that, with appropriate consideration for variations between STEM and STEAM focused activity, traditional sectoral cluster interventions can be adapted for the creative industries for the fashion and textile industry which sits naturally at the boundary between these two approaches.

Whilst the work of the UKRI Circular Fashion and Textile programme is still on-going it is already clear that co-design and co-delivery of U-I interventions will be essential to prepare the UK, and indeed the global, fashion and textile sector for sustainable transition. Industrial consultation has informed ecosystem development and focus so far and academic collaboration, rather than competition, is proving an insightful mechanism. Co-development of research strategies with sector bodies and industry partners ensures that an impact-first ethos runs throughout. Research project outcomes to date, from the LITAC-led Back to Baselines in Circular Fashion and Textiles project, focus on the significant challenges which face the global F&T sector with early outcomes targeting areas such as eco-credentials (Kesidou & Palm, 2024), Extended Producer Responsibility (European Commission, 2023; WEFT, 2025) and Ecolabels (Palm & Purnell, 2025). Reflections around co-opetition between HEIs to this end should be sifted and considered in light of the findings, currently direction of travel is collaborative whilst funding mechanisms remain primarily competitive creating tension in the system.

CRediT authorship contribution statement

Susan Rainton: Writing – review & editing, Writing – original draft, Project administration, Data curation, Conceptualization. **Kevin Almond:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The Future Fashion Factory programme is funded by the Arts and Humanities Research Council [grant ref. AH/S002812/1]

Data availability

The data that has been used is confidential.

References

Abbott, E. E., Cantalupo, J., & Dixon, L. B. (1998). Performance measures: Linking outputs and outcomes to achieve goals. *Journal of the Transportation Research Board, 1617*(1). https://doi.org/10.3141/1617-13

Almond, K. (2022). Virtual 3D garment draping as a service. *Fashion, Style & Popular Culture, 9*(4), 437–456.

Almond, K., & Rainton, S. (2025). Future fashion factory: Developing an ecosystem to support sustainable change. *International Journal of Fashion Design, Technology and Education*. https://doi.org/10.1080/17543266.2025.2454669

Archibugi, D., & Coco, A. (2004). International partnerships for knowledge in business and academia - A comparison between Europe and the USA. *Technovation, 24*, 517–528.

AWH. (2020). Sustainability report 2020. A.W. hainsworth; quality in textiles since 1783. https://www.awhainsworth.co.uk/wpcontent/uploads/2020/01/AW_Hainsworth_Sustainability_2020.pdf.

Bazalgette, P. (2017). Independent review of the creative industries. Retrieved from https://apo.org.au/sites/default/files/resource-files/2017-09/apo-nid198251.pdf.

Benghizo, P. J., & Paris, T. (2016). The cultural economy in the digial age: A revolution in intermediation? *City, Culture and Society, 7*(2), 75–80. https://doi.org/10.1016/j.ccs.2015.12.005

Bennett, T. (2020). The justification of a music city: Handbooks, intermediaries and value disputes in a global policy assemblage. *City, Culture and Society, 22*, Article 100354. https://doi.org/10.1016/j.ccs.2020.100354

BFC. (2024). *British fashion council - About*. British Fashion Council. Retrieved 08-Mar-2024 from https://www.britishfashioncouncil.co.uk/About.

Bjerregaard, T. (2010). Industry and academia in convergence: Micro-institutional dimensions of R&D collaboration. *Technovation, 30*.

Boldrini, J. C., Schieb-Bienfait, N., & Chene, E. (2011). Improving SMEs' guidance within public innovation supports. *European Planning Studies, 19*, 775–793. https://doi.org/10.1080/09654313.2011.561036

BOP Consulting. (2020). *Evaluating the CICP: CRDP engagement and background information*. BOP Consulting, commissioned by AHRC.

Bruneel, J., D' Este, P., & Salter, A. (2010). Investigating the factors that diminish the barriers to university-industry collaboration. *Research Policy, 39*, 858–868.

Carbonara, N. (2004). Innovation processes within geographical clusters: A cognitive approach. *Technovation, 24*(1), 17–28. https://doi.org/10.1016/S0166-4972(02)00046-9

CFIN. (2024). *The circular fashion innovation network (CFIN)*. Institute of Positive Fashion, UKFT & BFC. Retrieved 22-Aug-2024 from https://instituteofpositivefashion.com/The-Circular-Fashion-Innovation-Network#:~:text=UKRI%20supports%20the%20fashion%20and%20textile%20industry%20through,them%20to%20meet%20Net%20Zero%20Targets%20before%202050.

Choi, H., Park, S., & Lee, J. D. (2011). Government-driven knowledge networks as precursors to emerging sectors: A case of the hydrogen energy sector in Korea. *Industrial and Corporate Change, 20*, 751–787.

Clark, D. (2024). *Population of the United Kingdom in 2022, by region*. statista. Retrieved 08-Oct-2024 from https://www.statista.com/statistics/294729/uk-population-by-region/#:~:text=The%20population%20of%20the%20United%20Kingdom%20in%202022,by%20the%20North%20West%20England%20at%207.5%20million.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly, 35*(1), 128–152. https://www.jstor.org/stable/pdf/2393553.pdf?refreqid=fastly-default%3A34e26009256b50a2d390a2ae79403e46&ab_segments=&initiator=&acceptTC=1.

Colwell, J. (2024). *Reflective practice: Research methods*. Foundation Stage Forum Articles. https://eyfs.info/articles.html/teaching-and-learning/reflective-practice-research-methods-r263/.

Connor-Crabb, A., Bulmer, S., Bunyan, C., Guo, Y., Hulme, A., Rainton, S., Solomon, L., & Toms, S. (2025). *Sustainable and circular practices in the UK fashion and textiles industry*.

Crawford, N., & Dewfield, S. (2022). A design sprint for the creative industries sector vision. https://assets.publishing.service.gov.uk/media/62e10b63e90e0766b251ab73/Creative_Industries_Sector_Vision_Report_FINAL.pdf#:~:text=The%20Creative%20Industries%20are%20defined%20by%20DCMS%20as,through%20the%20generation%20and%20exploitation%20of%20intellectual%20property%E2%80%9D7.

DCLG. (2013). Yorkshire and the humber regional competitiveness and employment programme operational programme 2007-13. Retrieved from https://assets.publishing.service.gov.uk/media/5a7cd576ed915d6b29fa8f09/Y_H_Operational_Programme_revised_April_2013_.pdf.

Dwyer, M., Filieri, R., & O'Malley, L. (2022). Establishing successful university-industry collaborations: Barriers and enablers deconstructed. *The Journal of Technology Transfer, 48*, 900–931. https://doi.org/10.1007/s10961-022-09932-2

Ellams, D. L., & Postlethwaite, S. (2022). *Exploring designer-led R&D activities within fashion design and manufacture to drive technological and material innovations*.

Etzkowitz, H., & Klofsten, M. (2005). The innovating region: Toward a theory of knowledge-based regional development. *R & D Management, 35*, 243–255. https://doi.org/10.1111/j.1467-9310.2005.00387

Etzkowitz, H., & Leydesdorff, L. (1995). The triple helix – university-industry-government relations: A laboratory for knowledge based economic development. *EASST Review, 14*(1), 14–19. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2480085.

EURACTIV. (2011). EU pushes for better knowledge transfer. Retrieved 23-May-2011, from http://www.euractiv.com/en/science/eu-pushes-better-knowledge-transfer/article-171564.

European Commission. (2006). The new programming period 2007-2013: Indicative guidelines on evaluation methods: MONITORING AND EVALUATION INDICATORS; working document no. 2. In *DIRECTORATE-GENERAL regional policy; thematic development , I., evaluation and innovative actions; evaluation and additionality* (2nd ed.). Brussels: European Commission (EC). Retrieved from https://ec.europa.eu/regional_policy/en/information/publications/evaluations-guidance-documents/2006/indicative-guidelines-on-evaluation-methods-monitoring-and-evaluation-indicators.

European Commission. (2023). Circular economy for textiles: Taking responsibility to reduce, reuse and recycle textile waste and boosting markets for used textiles. https://ec.europa.eu/commission/presscorner/detail/en/ip_23_3635.

Eurostat. (2023). *Demography of Europe – 2023 edition*. European Union. Retrieved 08-Oct-2024 from https://ec.europa.eu/eurostat/web/interactive-publications/demography-2023#population-structure.

FFF. (2019). *R&D funding calls*. University of Leeds, Future Fashion Factory. Retrieved 22-Aug-2024 from https://futurefashionfactory.org/innovation/rd-funding-calls/.

FFF. (2022). *Future fashion factory: Supporting innovation in the UK fashion and textiles industry*. University of Leeds, Future Fashion Factory. Retrieved 06-Dec-2022 from https://futurefashionfactory.org.

FFF. (2023). *Future fashion factory announces interactive futures sustainable fashion (IFSF) challenge*. LITAC, FFF: University of Leeds. Retrieved 02-Nov-2024 from https://litac.leeds.ac.uk/ifsf/.

FFF. (2024a). *Fashion demonstrator: UKFT skills workshop*. LITAC/RCA/UKFT.

FFF. (2024b). 02-May-2024). *FFF spring EXPO: Closing remarks*. University of Leeds, Future Fashion Factory. https://futurefashionfactory.org/.

FFF. (2025). *Digitally enabled design & manufacture of designer products for circular economies*. L. University of Leeds https://litac.leeds.ac.uk/fff-programme-publication/.

FFN+. (2024). Future fibres network+. *University of Exeter, Future Fibres Network+*. Retrieved 22-Aug-2024 from https://futurefibresnetworkplus.com/.

Fiore, A., Grisorio, M. J., & Prota, F. (2011). Regional innovation systems: Which role for public policies and innovation agencies? Some insights from the experience of an Italian region. *European Planning Studies, 19*, 1399–1422.

Freel, M. S. (2003). Sectoral patterns of small firm innovation, networking and proximity. *Research Policy, 32*, 751–770.

George, T. (2022). *Mixed methods research | Definition, Guide, & Examples*. Scribbr. https://www.scribbr.co.uk/research-methods/mixed-methods/.

Gilmore, A., & Burnill-Maier, C. (2025). Creative improvement, cultural infrastructure and urban zones: A tale of three cities and their cultural districts. *City, Culture and Society, 41*, Article 100466. https://doi.org/10.1016/j.ccs.2025.100634

Gnyawali, D. R., & Park, B. J. (2011). Co-opetition between giants: Collaboration with competitors for technological innovation. *Research Policy, 40*, 650–663.

GOV.UK. (2021). *Business population estimates for the UK and regions 2021*. statistical release. https://www.gov.uk/government/statistics/business-population-estimates-2021/business-population-estimates-for-the-uk-and-regions-2021-statistical-release-html.

GOV.UK. (2024). *Business population estimates for the UK and regions 2024: Statistical release*. UK Government Website, Department for Business & Trade. Retrieved from https://www.gov.uk/government/statistics/business-population-estimates-2024/business-population-estimates-for-the-uk-and-regions-2024-statistical-release#:~:text=SMEs%20accounted%20for%2060%25%20of,as%20shown%20in%20Figure%209.

Hassan, M. (2024). Content analysis – Methods, types and examples. Retrieved 25-Mar-2024, from https://researchmethod.net/content-analysis.

Heinze, T., & Kuhlmann, S. (2008). Across institutional boundaries? Research collaboration in German public sector nanoscience. *Research Policy, 37*, 888–899.

Hemingray, C., Vecchi, A., Bonetti, F., Toms, S., Bulman, S., Connor-Crabb, A., Guo, Y., Silva, E. S., & Solomon, L. (2023). *Impact of brexit and Covid-19 on the UK fashion and technology ecosystem*. University of Leeds/University of the Arts London. Available at https://ukft.org/report-brexit-covid-bftt-fff/.

Hewitt, A., Rana, S., & Goswami, P. (2023). Development of novel parameters for characterising scale morphology of wool fibre and its correlation with dye diffusion coefficient of acid dye. *Scientific Reports, 13*(1), 1–13.

HMRC. (2024). Digital readiness check. https://www.gov.uk/government/publications/digital-readiness-check/digital-readiness-check. Retrieved from.

Huggins, R., & Johnston, A. (2009). Knowledge networks in an uncompetitive region: SME innovation and growth. *Growth and Change, 40*, 227–259.

IMPACT+. (2024). *IMPACT+Index measures promoting assessment and circular transparency in fashion*. Northumbria University. Retrieved 22-Aug-2024 from https://hosting.northumbria.ac.uk/impactplusnetwork/.

Independent. (2016). STEM vs. STEAM: How the sciences and arts are coming together to drive innovation. *The Independent (UK edition)*. Retrieved 21-Jan-2025, from https://www.independent.co.uk/student/student-life/studies/stem-vs-steam-how-the-sciences-and-arts-are-coming-together-to-drive-innovation-a7047936.html.

Innovation Partnership. (2024). Centres of industrial collaboration (CIC). *Innovation Partnerships Ltd*. Retrieved 15-Oct-2024 from https://www.theinnovationpartnership.com/our-work/centres-of-industrial-collaboration.

IoDS. (2024). *Reflective Practice*. Retrieved 15-Oct-2024, from https://www.participatorymethods.org/method/reflective-practice#:~:text=Reflective%20practices%20are%20methods%20and%20techniques%20that%20help,behaviour%20%E2%80%93%20that%20shape%20our%20thinking%20and%20action.

IUK. (2024). *The industrial strategy challenge fund* [youTube channel - Dedicated to ISCF]. https://www.youtube.com/watch?v=fOuoSdFWK7Y,InnovateUK(IUK. https://www.youtube.com/watch?v=fOuoSdFWK7Y.

IUK. (2025a). Empowering innovation by connecting businesses with experts. *IUK*. Retrieved 14-Jan-2025 from https://iuk-ktp.org.uk/.

IUK. (2025b). IUK business connect: We create diverse connections to drive positive change. *IUK*. Retrieved 14-Jan-2025 from https://iuk-business-connect.org.uk/.

Kelly, S. M., & Rainton, S. (2010). *Nanofactory: The commercialisation of nanotechnology in the yorkshire & humber region*. Bradford, UK: ENGAGE HEI.

Kesidou, E., & Palm, C. (2024). *Eco-credentials in the fashion and textile industry assessment and evaluation: A review of eco-credentials, their strengths and weaknesses, and recommendations for improvement*. University of Leeds. available at https://ssrn.com/abstract=5052003 https://papers.ssrn.com/sol3/papers.cfm?abstract_id=5052003.

Ketels, C., Lindqvist, G., & Solvell, O. (2008). *Clusters and cluster initiatives*.

Leeds City Region LEP. (2020). Ide@ driving innovation - The team. *Leeds city region LEP*. Retrieved 2023-10-24 from https://idealeedscityregion.com/the-team/.

Leydesdorff, L., & Meyer, M. (2006). Triple helix indicators of knowledge-based innovation systems - Introduction to the special issue. *Research Policy, 35*, 1441–1449. https://doi.org/10.1016/j.respol.2006.09.016

LITAC. (2024). *Back to baselines*. LITAC: University of Leeds. Retrieved 22-Aug-2024 from https://backtobaselines.leeds.ac.uk/.

Lu, C., Qi, Y., & Hao, S. (2023). Enhancing innovation performance of SMEs through open innovation and absorptive capacity: The moderating effect of business model. *Technology Analysis and Strategic Management, 36*(10), 2907–2923. https://doi.org/10.1080/09537325.2023.2177827

Luukkonen, T. (1998). The difficulties in assessing the impact of EU framework programmes. *Research Policy, 27*, 599–610.

McAdam, R., Miller, K., McAdam, M., & Teague, S. (2012). The development of university technology transfer stakeholder relationships at a regional level: Lessons for the future. *Technovation, 32*, 57–67.

Montague, S. (2000). Focusing on inputs, outputs, and outcomes: Are international approaches to performance management really so different? *Canadian Journal of Program Evaluation, 15*(1). https://doi.org/10.3138/cjpe.015.008

Nanofactory. (2012). *Partnerships for new technology*. Nanofactory: University of Leeds. Retrieved 15-Oct-2024 from https://www.nanofactory.org.uk/.

ONS. (2023). UK public-funded gross regional capital and non-capital expenditure on research and development: Financial year ending 2021. Retrieved 17-Apr-2023, from https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/researchanddevelopmentexpenditure/articles/ukpublicfundedgrossregionalcapitalandnoncapitalexpenditureonresearchanddevelopment/financialyearending2021#:~:text=The%20UK's%20public%2Dfunded%20gross,%C2%A31.3%20billion%2C%209.5%25.

OR. (2025). Absorptive capacity: Definition and explanation. *Oxford Review*. Retrieved 22-Jan-2025 from https://oxford-review.com/oxford-review-encyclopaedia-terms/encyclopaedia-absorptive-capacity/.

OSTP. (2014). *The 2015 Budget: Science, Technology, and Innovation for Opportunity and Growth. Science, Technology, Innovation, and STEM Education in the 2015 Budget*. United States government Retrieved from https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/Fy%202015%20R&D.pdf.

Palm, C., & Purnell, P. (2025). Are ecolabels meaningful and reliable? A critical review of UK textile and fashion certification. https://eprints.whiterose.ac.uk/id/eprint/229158/.

Perspective Economics. (2021). University of Leeds//fashion, textiles + colour – Research & innovation capacity, capabilities and potential. *N/a*.

Petruzzelli, A. M. (2011). The impact of technological relatedness, prior ties, and geographical distance on university-industry collaborations: A joint-patent analysis. *Technovation, 31*, 309–319.

Porter, M. (2000). Location, competition, and economic development: Local clusters in a global economy. *Economic Development Quarterly, 14*(1). https://doi.org/10.1177/089124240001400105

Pratt, A. C. (2021). Creative hubs: A critical evaluation. *City, Culture and Society, 24*, Article 100384. https://doi.org/10.1016/j.ccs.2021.100384

Rainton, S. (2012). *When does regionally focused funding really make regional SMEs innovate and how? (upgrade document: 200584680)* [PhD Upgrade Document, University of Leeds].

Rainton, S., Harris, J., & Russell, S. J. (2025). *Innovation Funding for UK Fashion and textiles: An overview of R&D mechanisms to support collaborative, industry-led academic research* [fashion demonstrator report, FD D2]. https://litac.leeds.ac.uk/innovation-funding-report/.

Rawsthorne, C., Solanki, A., Chatterton, P., & Brooks, J. (2022). The first Leeds doughnut city portrait: Towards a safe and thriving city for all. *L. Climate Action Leeds, UK*. htt

ps://www.climateactionleeds.org.uk/_files/ugd/6c95b1_9d4dec776a724feabdc443a84527c45f.pdf.
Read, K. (2024). *Post-1992 universities: What does peter brady say about evolution?* University Business. Retrieved 14-Jan-2025, from https://universitybusiness.co.uk/peter-brady-on-the-evolution-of-post-1992-universities/.
Robson, P. J. A., & Bennett, R. J. (2000). SME growth: The relationship with business advice and external collaboration. *Small Business Economics, 15*, 193–208.
Roper, S. (1997). Product innovation and small business growth: A comparison of the strategies of German, UK and Irish companies. *Small Business Economics, 9*, 523–537. https://link.springer.com/article/10.1023/A:1007963604397.
Russell, S. J. (2018). *(AH/S002812/1) [grant]. Yorkshire and the Humber/UK-wide*.
Russell Group. (2025). About: Our universities. Retrieved 14-Jan-2025 from https://russellgroup.ac.uk/about/our-universities/.
Scaife, J. (2010). *Supervising the reflective practitioner: An essential guide to theory and practice*. Routledge.
Schalock, R. L., & Bonham, G. S. (2003). Measuring outcomes and managing for results. *Evaluation and Program Planning, 26*(3). https://doi.org/10.1016/S0149-7189(03)00027-2
Schon, D. (1983). The reflective practitioner. Routledge. Statista. (2024). Population of the United Kingdom in 2023, by region. Retrieved 13-Jan-2025, from https://www.statista.com/statistics/294729/uk-population-by-region/.
Statista. (2024). *Population of the United Kingdom in 2023, by region*. Retrieved 13-Jan-2025, from https://www.statista.com/statistics/294729/uk-population-by-region/.
TCoE. (2023). Textile centre of excellence: About us. Retrieved 12-Jan-2025 from https://tcoe.co.uk/about-us/.
Teal, J., Kusev, P., Peebles, D., Vukadinova, S., Buontempo, M., Martin, R., & Ngo, B. T. (2022). *How perceived privacy risk determines people's willingness to use online fashion technologies 63rd annual meeting of the psychonomic Society*. Boston, United States, Massachusetts.
TSB. (2008). *Connect and Catalyse: A strategy for business innovation 2008-2011*. Swindon, UK: UK Government, Technology Strategy Board (TSB).
UAL. (2024). Business of fashion, textiles and technology. *UAL, BFTT*. Retrieved 02-Nov-2024 from https://bftt.org.uk/.
UKFT. (2021). New supply chain platform to drive sustainability, transparency and profitability in UK fashion and textiles. https://ukft.org/supply-chain-platform/.
UKFT. (2024a). About UKFT. Retrieved 08-Mar-2024 from https://www.ukft.org/about/.
UKFT. (2024b). Automatic-sorting for circularity in textiles (ACT UK). *UKFT*. Retrieved 22-Aug-2024 from https://ukft.org/innovation/act-uk/#:~:text=ACT%20UK%20is%20a%20two,%2C%20technologists%20and%20brands%2Fretailers.
UKRI. (2017). *UKRI challenge fund: For research and innovation. Department for science, innovation and Technology, UK Research and Innovation (UKRI); Innovate UK (IUK)*. Department for Business, Energy & Industrial Strategy (BEIS). Retrieved 09-Oct-2024 from https://www.gov.uk/government/collections/industrial-strategy-challenge-fund-joint-research-and-innovation.
UKRI. (2023a). Areas of investment and support: Creative industries clusters programme. *UKRI*. Retrieved 05-Mar-2024 from https://www.ukri.org/what-we-do/browse-our-areas-of-investment-and-support/creative-industries-clusters-programme/.
UKRI. (2023b). Creative industries clusters programme. Retrieved 21-Aug-2024 from https://www.ukri.org/what-we-do/browse-our-areas-of-investment-and-support/creative-industries-clusters-programme/.
UKRI. (2023c). UKRI circular fashion and textile programme: NetworkPlus. *UKRI*. Retrieved 21-Oct-2024 from https://www.ukri.org/opportunity/ukri-circular-fashion-and-textile-programme-networkplus/.
UKRI. (2024a). About innovate UK. *UKRI*. Retrieved 02-Nov-2024 from https://www.ukri.org/who-we-are/innovate-uk/.
UKRI. (2024b). *About NERC*. UKRI. Retrieved 02-Nov-2024 from https://www.ukri.org/who-we-are/nerc/.
UKRI. (2024c). *Who AHRC is*. UKRI. Retrieved 05-Mar-2024 from https://www.ukri.org/who-we-are/ahrc/who-we-are/.
UKRI. (2025). *UKRI: Who are we*. UKRI. Retrieved 19-Jan-2025 from https://www.ukri.org/who-we-are/.
WEFT. (2025). Visible EPR charges on clothing: Consumer responses and policy implications [Policy briefing] https://www.weft.org.uk/_files/ugd/e7fc89_d8bbceb44554406a95d8a438b5d70569.pdf.
Williams, R. (2010). *Nanofactory [grant]. Yorkshire and humber*.
Williamson, J. (2019). Future fashion factory: Weaving a new future for a historic industry. *The Manufacturer*. Retrieved 13-Jan-2025, from https://www.themanufacturer.com/articles/future-fashion-factory-weaving-a-new-future-for-a-traditional-industry/.
Willment, N., Swords, J., & Murphy, D. (2025). XR stories as innovation and cultural intermediary for the creative industries. *City, Culture and Society, 42*, Article 100653. https://doi.org/10.1016/j.ccs.2025.100653
WRAP. (2023). *Textiles 2030 annual progress report 2022/23*.
Wyca, L.-L. (2016). Leeds city region strategic economic plan 2016-2026. Retrieved from https://www.westyorks-ca.gov.uk/media/1110/strategic-economic-plan.pdf.
XRStories. (2025). *XR network+*. XR stories. Retrieved 19-Jan-2025 from https://xrstories.co.uk/about/networkplus/.
YF. (2006). Yorkshire and the humber, regional competitiveness and employment programme, operational programme 2007-2013. *Yorkshire and the humber, UK: European regional development fund (ERDF)*.