The Journal of Technology Transfer
https://doi.org/10.1007/s10961-023-10043-9

An empirical investigation into UK university–industry collaboration: the development of an impact framework

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Accepted: 13 October 2023

Abstract

Providing evidence of the impact of university–industry (U–I) partnerships is challenging. This empirical research contributes to this thought-provoking subject area by developing an impact assessment framework to assess the effect of collaboration between university and industry. This is examined through a multiple case study approach: 13 partnership schemes, each of two years duration, in manufacturing and healthcare. This study demonstrates that effective knowledge transfer from universities to enterprises is not only hypothetically feasible, but also realistically tangible and measurable. It explores how Business and Management Schools transfer knowledge and technology through external interventions and formal partnership schemes. Our findings show that impact and knowledge transfer can be evaluated, but requires active facilitation before, during and after the project, plus a level of openness and expert engagement within the partnerships. Additionally, our findings established that healthcare partnerships generated higher perceived levels of impact than manufacturing. This perhaps indicates that further work is necessary to resolve the issues limiting the productivity gains of manufacturing partnerships.

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Published online: 13 November 2023

Keywords University–industry collaboration · Impact · Knowledge transfer

1 Introduction

Universities are viewed as a source of new ideas, technologies and innovation (Anderson et al., 2007; Bruneel et al., 2010; Henderson et al., 1988) and brokers to new knowledge (Perkmann et al., 2021) to create impact (Reed et al., 2021), all of which can potentially make a contribution to industry and society. Drawing upon the work of Reed et al. (2021) we identify the concept of impact within the context of university-industry (U–I) collaboration as both tangible and intangible, as objective and subjective improvements, outputs, and influences resulting from a partnership. We consider that impact encompasses various dimensions including knowledge transfer and dissemination, innovation diffusion, product and service commercialisation, workforce development, strategy deployment and technology advancement. We therefore define the term 'impact' as being tangibly associated with increased capability, e.g. going beyond cost-cutting and incremental performance improvement to develop organisational capabilities. Improving operational capabilities through investments in people, technologies and processes is key to maximising business impact, which can potentially be measured. Business operations impact can be associated with increased organisational capabilities related to quality, cost, speed, flexibility and innovation (Bamford et al., 2023). Developing such capabilities leads to sustainable performance improvement. Considering the characteristics of impact is particularly important, as governments increasingly require universities and other recipients of public funding to demonstrate their contribution at the level of practice and policy. This is a direct application of what we, in academia, would regard as planning, governance and control—being able to more reliably evidence or even predict the degree of impact or the potential return on investment (Alexander & Childe, 2013). The engagement of universities assisting firms through knowledge exchange is not just for innovative products or services (Caloghirou et al., 2021) but for generating innovative working practices, supporting the enhancement of operational and strategic capabilities through adoption of better practice and systems (Tucker & Singer, 2015). However, as reported by several authors (Binder & Clegg, 2006; Saad et al., 2017; Seno Wulung et al., 2018) and most recently by Reed et al. (2021), difficulties exist with evaluating, assessing and measuring the impact of such U–I partnership, due to a lack of control of the implementation, the spillover effect and knowledge creep, the inconsistent and partial access to appropriate data, and importantly the inconsistent rate of absorption depending on the sector, type of organisation and culture (Maguire, 2012). In addition to this, measuring the impact generated through the development of organisational capabilities is challenging because those capabilities are increased via a set of individual but complementary actions on multiple levels. These potentially influence the organisational performance (Wójcik & Ciszewska-Mlinarič, 2020) and there is also non-linear impact generated by such multi-dimensional concepts (Wang & Feng, 2019). The generation of such multi-level impact can inform and shape the organisational business model, therefore, to investigate and assess the level of impact of U–I collaboration, we have adapted an extended-Ansoff matrix and analysed a sample of 13 U–I knowledge transfer partnerships (known as KTPs). These seven cases from manufacturing and six cases from healthcare were each of 2-year duration. We focused on the dyadic relationship between a university and a firm and investigated the impact at this level rather than from a network perspective.

Two research questions were developed: (i) How to evidence and capture the impact generated by U–I knowledge transfer projects?; (ii) What are the differences in impact between manufacturing (private sector) and healthcare (UK public sector) U–I partnership projects? In exploring the above, the paper develops a framework to assess U–I collaboration and impact. The study attempts a contribution that is rigorous and relevant through an empirical investigation (Anand et al., 2010; Li et al., 2012) by considering both the theoretical and practical problems of knowledge transfer, and the impact of longitudinal U–I engagement. Our analysis demonstrates how and to what extent manufacturing and healthcare organisations have benefited from U–I knowledge transfer partnerships. The study shows that healthcare organisations tend to benefit more from university collaboration regarding knowledge transfer than manufacturing firms.

2 Literature review

To begin the positioning of our exploration regarding evaluating, assessing and measuring the impact of U–I partnerships we present three interrelated sections. Firstly, what theoretical underpinnings exist to inform what knowledge transfer is?; secondly, how are U–I collaborations defined within the literature?; and lastly, in simple terms, how is research impact defined in the literature, and what are the potential knowledge gaps regarding this aspect. In order to set clear boundary conditions for this research we focus on the dyadic relationship between a university and an organisation, which has informed this theoretical review.

2.1 What is knowledge transfer?

Knowledge is perceived as a key driver of entrepreneurial alertness and creativity (Gaimon & Bailey, 2013; Meredith & Pilkington, 2018), with knowledge transfer being frequently cited objectives and aspirations for policy makers, businesses and universities alike (Bamford et al., 2011; De Wit-de Vries et al., 2019). If executed positively, such transfer should have benefits for all three groups, and for society as a whole. These are represented very well in the UK via the Knowledge Transfer Partnership (KTP) scheme which takes a more sophisticated approach rather than a linear one-way knowledge transfer. Several authors have recognised that companies in various industries have increasingly accepted the importance of scientific knowledge creation and technological opportunities, seeking alliances to enhance their knowledge base (Hewitt-Dundas, 2013; Saad et al., 2017), in the hope of gaining a competitive edge. Alexander and Childe (2013) and Anand et al. (2010) touched on this phenomenon, exploring aspects of 'tacit' and 'explicit' knowledge transfer, and the ability of a public or private organisation to assimilate and put in place external sources of knowledge is critical for their future sustainability (Lewin et al., 2011; Patel et al., 2012; Roper et al., 2017; Volberda et al., 2010). In their paper, Azagra-Caro et al. (2017) demonstrated that the impact from such transfer is only achieved after a complex and dynamic sequence of events and interactions between the parties, which can be generated through formal and informal mechanisms. Saad et al. (2017) identified that awareness (the importance, motivation and interest of learning and innovation) was an antecedent dimension of the concept of absorptive capacity in manufacturing SMEs, and Pérez-Salazar et al. (2019), reporting on their systematic literature review on supply chain research, identified that knowledge transfer was discussed in the majority of studies reviewed, demonstrating the understanding of it as a concept.

Reporting on their research which conveyed a conceptual framework to show how enterprise structures emerge, Binder and Clegg (2006) presented a conceptual framework based on an exploratory study in the German automotive industry. They proposed useful contingency planning recommendations to facilitate the management of change. In a related paper, Kent and Siemsen (2018) reviewed a number of knowledge transfer templates across different dimensions when transferring process knowledge. They suggest that templates (frameworks) are an important aspect of the process, and that their benefit is not because initial performance increases as a result of using them, rather that learning happens at a much faster rate—although this is always difficult to assess. But there are limited usable frameworks for evidencing transfer, whether for practical purposes or for structuring research investigation (Levine, 2017). A major issue here is that projects entitled 'technology' transfer are often seen predominantly from a technical perspective by those involved, whereas most projects are clearly more a transfer of expertise, know-how and human capital between parties (Bamford et al., 2011). Technology transfer is often reviewed at a policy level (e.g. Spring et al., 2017), as indicated from the literature, but there are fewer studies exploring the phenomenon at project level (Upton et al., 2014). More project-level analysis is, therefore, needed, so the research upon which this paper is based tackles technology and knowledge transfer on a project-by-project basis (c.f. Rahmani, et al., 2017).

2.2 University-Industry U–I collaboration

From a historical standpoint, U–I partnerships have grown significantly in the past 30 years but have recently accelerated, with an impetus for innovation, technology transfer and strategy and policy deployment (Bruneel et al., 2010; D'Este et al., 2019; Lee & Miozzo, 2019). U–I partnerships have been key in the growth of knowledge-based economies (De Silva et al., 2021) and are increasingly important in developing countries. Studies have analysed the process of knowledge transfer between universities and firms, focusing on specific knowledge outputs like research publications and policy changes (Reed, 2018). However, recently, De Silva et al. (2021) investigated the subjective perception of partnerships and demonstrated the impact on the objective outcomes. Bruneel et al. (2010) analysed the issues preventing deep collaborations between businesses and universities. They explored various factors that lower the barriers such as inter-organisation trust, collaboration experience and nature of the interactions. Nsanzumuhire and Groot (2020) performed a systematic review of the literature and their findings showed that despite the proliferation of publications, there are still knowledge gaps. This backdrop provides the rationale for undertaking this research. Moreover, there have been some notable contributions to the field of technology and knowledge transfer, which have relevance to the current study (Anderson et al., 2007; Bekkers and Bodas Freitas 2008; Binder & Clegg, 2006; Hewitt-Dundas, 2012; Jin et al., 2018; Lee & Miozzo, 2019; Olmos-Penuela et al., 2014; Pérez-Salazar et al., 2019; Reed, 2018; Reed et al., 2021; Sengupta & Ray, 2017; Seno Wulung et al., 2018; Wu et al., 2021). Several authors have raised issues of the assumptions made by university partnerships (Aalbers et al., 2014; Argote & Hora, 2017; Mom et al., 2015; Radaelli et al., 2014), suggesting that the reality of application is different, that firms and organisations have diverse levels of experience and perception of innovation, absorptive capacity, partnership and trust. Realistically, these will vary significantly between the type of sector, the industry and the business culture and attributes of the organisation, such as its maturity, know-how, and structure. This goes towards De Silva et al.'s (2021) findings. Interestingly, some researchers have stressed that more experienced practitioner-based organisations in U–I collaboration appear to be willing to provide additional support for knowledge transfer to industry (D'Este & Patel, 2007; Reid et al., 2019).

2.3 Knowledge gaps and research impact

As positioned within the introduction, we define the term 'impact' as being related to increased capability. Put another way, the marked effect or influence on the organisation and the connectivity across the relationship, in line with De Wit-de Vries et al. (2019). Reed et al. (2021) reported that there is no shortage of methods for evaluating impact, and that the challenge lies in choosing the most appropriate given the context. We believe that a reason for the lack of common holistic frameworks is because technology and knowledge transfer can be subjective as well as intangible and defined / interpreted in many ways (Bamford et al., 2011; De Silva et al., 2021). The notion of impact does appear to vary depending on the type of organisation, such as the sector, the industry, the range of stakeholders involved, the firms' culture (Maguire, 2012). For example, Ter Wal et al. (2017) reported on how gatekeepers focus their efforts on identifying and assimilating with external knowledge flows in order to promote utilisation and potential absorptive capacity and Saad et al. (2017) examined manufacturing SMEs and determined that awareness was an antecedent dimension to improve their knowledge base resources. It is also interesting to note that Perkmann et al. (2021) suggested that academic engagement is a social condition with peer effects that result in commercial and society-wide impact. In order to sustain this notion, they called for more longitudinal surveys and for some standardisation of engagement measures. Awasthy et al. (2020) explained that measures and best practice have been proposed and disseminated to improve collaboration effectiveness, however, more holistic frameworks would be valuable and meaningful.

The potential contribution for our research, therefore, is to examine the dyadic relationship between a University and Industry (a firm), and how the impact of this collaboration can be perceived and defined as both tangible and intangible, objective and subjective. We seek to examine the influences and outputs resulting from the period of engagement and exchange.

3 Methodology

3.1 The sample

The primary sources of data involved the collection and collation of sets of documentation for 13 two-year publicly funded Knowledge Transfer Partnerships. These projects involved seven private manufacturing firms and six public healthcare organisations. This sample of projects was chosen for a number of reasons: (i) The difference between them (manufacturing / healthcare), one being private sector (manufacturing) the other public sector (UK healthcare); (ii) The importance, influence and significance of these two sectors, (e.g. 2018 Gross Domestic Product (GDP) in manufacturing for UK = 8% (The World Bank, 2021); 2019 (GDP) in the healthcare sector for UK = 9%); (iii) Convenience of the sample (c.f. Yang et al., 2021), as it is based on extensive projects that the author team were involved with, had full data and continued access to (note that aspects of bias in this were accounted for, as per Hardcopf et al., 2017). All selected cases offered insight that enabled the authors to explore the phenomenon under investigation, within the context of cross functional knowledge exchange (Guo et al., 2017; Li et al., 2012). Eisenhardt and Graebner (2007) clearly posit that the adoption of multiple cases offers a robust and generalisable analysis, highlighting that the analysis of the rich empirical case data (c.f. Anand et al., 2010; Li et al., 2012) enables exploration of research questions and makes a significant contribution to theory, and developing well-crafted tables provides an effective way to present the case evidence and underline the richness of case data.

3.2 The data

Reed et al. (2021) state that the diversity of benefits and perceptions of benefits arising from research presents a methodological challenge for evaluating impact. An important note is that each of these projects had a formal requirement for exactly the same type of documents to be created at key stages. These included for example: the initial bid document (10,000 words average); a detailed ‘work plan’ (5000 words average); 6 ‘in progress’ reports (of between 2000 and 6000 words each); the project final report (12,000 words average). Data were therefore gathered from before, during and after each project. To obtain the public funding, an extensive formal bid submission had to be jointly created for each project (by both parties, the company and the university), which averaged 10,000 words per bid. We analysed these key artefacts (formative formal documents) and transcripts using the procedures described in Miles and Huberman (1994, 58–62) and Tucker and Singer (2015, 261). This activity outlined the focus, scope, scale and ambition of the project—aided by the provided work plans, the projected key performance indicators and specific targets. During each project the tangible benefits were reported throughout via regular documented meetings, where the associate and the project team (the academic and the industry partners) reported on the project progress and set future short-term direction, as well as highlighted potential risks and required changes (Lui et al., 2017). Consequently, there were six in-progress reports during each project’s life cycle, which averaged 6000 words per report (so 36,000 words per project). These in-progress reports included a benefits log which captured the impact of the project through a range of both financial and non-financial measures. These artefacts formed the foundation for the project final reports – a UK Government (the funding provider) requirement to capture and measure outcomes of the undertaking, (see Appendix, for detail on the artefact timeline). These documents, written jointly by the project team, were the main dissemination mechanisms for the stakeholders (the funding body, the company, the university) to assess, measure and report the project contributions and impact in terms of, for example: new business practices and partnerships; processes and products; estimating the return investment; strategic alignment and deployment; organisational performance; and the development of a potential competitive advantage (Bhattacharjee & Chakrabarti, 2015; Hardcopf et al., 2017; Ram et al., 2014; Soloducho-Pel,c 2014; Su et al., 2014). The project joint final report averaged 8000 words per project, and the project associate report 4000 words per project (12,000 words combined). Table 1 summaries how these key sources of information, which averaged a total of 58,000 words per project (approx.), were used to assess the effectiveness of the knowledge.

The key points presented in the findings section were extracted from the available data via collation and coding, by two members of the author team to ensure consistency and reliability of the analysis and coding across projects. This process involved: (i) thematic analysis by the two members of the author team; (ii) meetings with multiple stakeholders from

Table 1 Data coding framework used in this research into Knowledge Transfer Partnerships (KTPs)

Key sources of information	Variables	Measured outcomes	New capabilities
Bid document (10,000 words avg) Workplan (5000 words avg) In progress reports at key project stages (6000 words avg) Final reports (12,000 words avg)	Degree of improvement in efficiency or productivity	Improvements in business processes and customer service—cycle time reduced by 18.75% Increased number of customers—77% patients would use the service again Evidence of applying innovation—Lean Six Sigma Publication outputs from the case study data	Competitive position at end of project/enabling variables
In progress reports (6000 words avg) Final KTP reports (12,000 avg)	The aim of the project and the defined areas for improvements	Investments derived from the results of the KTP: In plant, machinery and buildings In employing new staff in training staff Restructuring and reporting	Investment directly related to the KTP project, operational visibility and transparency
Bid document (10,000 words avg) In progress reports (6000 words avg) Final KTP reports (12,000 words avg)	The aim of the project and the need of new knowledge and capabilities	Performance measurement systems Evidence-based decision-making Lean/Six Sigma methodologies Redesign and knowledge management tools and techniques Benchmarking Team working skills Audits and checklists Standard Operating Procedures (SOPs) Communication strategy and reporting structures	Staff development in terms of knowledge/skills/competencies
In progress reports/ (6000 words avg) Final KTP reports (12,000 avg)	The degree of Impact U–I collaboration for industry	Cost savings—25% reduction in costs of ad-hoc journeys 20% increase in export sales Future cost savings: 3 times the annual savings over the next 3 years (on average)	Cost saving generated/projected future cost savings

Table 1 (continued)

Key sources of information	Variables	Measured outcomes	New capabilities
In progress reports / (6000 words avg) Final KTP reports (12,000 avg)	The degree of Impact U–I collaboration for industry academic institutions	Journal/Conference Publication Case study/Teaching material Student projects Guest speakers Site visits	Impact for the academic institution/dissemination of results

each project to review and agree upon the partnership impact and outputs. These meetings followed a stipulated standard agenda (re-introductions, outline of purpose, review of key documents and data, record of agreed project impact) and details were precisely logged; and (iii) re-review and analysis by the author team.

Once the above activities were completed the data were gathered and analysed using an inductive thematic analysis (c.f. Binder & Clegg, 2006; Corbin & Strauss, 2014; Fereday & Muir-Cochrane, 2006) and co-production techniques (Rahmani et al., 2017) by the same two members of the author team. The developed themes were: (i) the new/improved capabilities of the organisation at the end of the project and the variables to measure this; (ii) the cost saving generated and any projected future savings; (iii) the impact of the cost savings; (iv) investments made by the company; (v) the staff development in terms of knowledge, skills and competencies; (vi) the impact of institutional teaching; (vii) the impact on the university partner; and (viii) the dissemination of results.

3.3 Development of a knowledge flow matrix

Joglekar et al. (2016) suggest that case studies considering evidence from multiple industries provide a unique opportunity for developing research methodological innovation. The challenge in this, according to Reed et al. (2021), is that impact evaluation needs to be designed with both the context and the aim of the evaluation in mind. To this end, a key element of this research for the author team was the opportunity to create a means of demonstrating the impact from university–industry collaborations. The matrix developed by Ansoff (1957) of product (x-axis) and market (y-axis) growth, to show that products and markets are interdependent and inter-determining (Finch & Geiger, 2011), provided some inspiration to the current study, as did Binder and Clegg (2006) with the development of their Reference Grid which displayed how an enterprise structure could change as a result of core competence development.

Sharifi et al. (2009) extended the Ansoff Matrix to demonstrate the transitions a firm can experience from the market starting position. Their contribution was in highlighting that business settings change, and the particulars of each industry will influence the type of criteria result in impact, and that the criticality of these elements can only be derived from an in-depth appreciation of the context. This concept is advanced in our paper where we have adapted Sharifi et al.'s (2009) matrix, developing the idea further to allow evaluation regarding the knowledge flow across collaborations, and we have replaced the product-market axis labels with Capability (on the x-axis labelled as Industry Capability) and Resource Base (y-axis). For the purpose of our research the Industry Capability is defined as the external aspects (e.g. customers, competition, technologies, the business environment, etc., as per Sharifi et al., 2009), and Resource Base as those elements within internal operational control (e.g. knowledge capital, staff, infrastructure, processes and procedures, innovation, suppliers, services, materials, etc., as per Dale, Bamford, and van der Wiele 2016).

Regarding the meaning of the 'Existing – Extended – New' axis progression, this was inspired by Ansoff (1957), Hayes and Wheelwright (1984) and Sharifi et al. (2009). We define the Industry Capability (x-axis) progression regarding 'Existing – Extended – New' in the following manner: Existing refers to a neutral starting point, one where existing sales or provision of service are as expected; Extended denotes 'more' sales or provision of service from the current offering; New signifies different customers or perhaps different, innovative and novel products and services. We define the Resource Base (y-axis) progression regarding 'Existing – Extended – New' as: Existing means a neutral starting point, where process operations and capacity are fit for purpose (e.g. the operations element is doing no harm); Extended is where organisations perceive the process operations for a particular unit are enhanced and add value, perhaps through efficiency and cost gains, operational design or innovation; New is perhaps perceived as risky but offers the organisation more, through fundamental redesign products or services, or operational restructuring. The matrix was developed a-posteriori rather than a-priori to develop a usable impact assessment framework. Please see Fig. 1.

The perceived organisational impact of each project was assessed by the project team (the organisation stakeholders and the authors) based upon the available evidence. Firstly, each project team was presented with the analysis performed by the two members of the author team who had conducted the analysis and based solely on the evidence presented in the documents described above (please see Table 1 and Appendix). Secondly, this placement was then discussed by the project team to take account of contextual factors that could affect the assessment of an impact (for example the difference between what the health care organisations viewed as an impact as compared to the manufacturing organisations), before a final placement was agreed. Although this approach might be viewed as subjective in nature it was considered an essential step to allow the contextual factors to be taken into account. This improved method of applying available longitudinal data shows agreed transition and perception of impact, which according to Nagati and Rebolledo (2013) is very useful as it provides a better understanding of the relationships between variables.

During this phase, meetings were held with each organisation and they were each placed within a cell (and assigned a score within the cell between 0 and 10) of the developed University-Industry Knowledge and Impact Flow Matrix. These determinations reflected the evidence-based perception of the part of the organisation involved in the U–I collaboration, assigning their position pre-project, and then their position post-project. The placement within each cell, and the score between 0 and 10 for the Increased Capability (horizontal) and the Resource Base (vertical) axis, attempted to position the organisations as precisely as possible. The impact scores demonstrate the starting points and observed transitions achieved in each project, and these are presented in the next section.

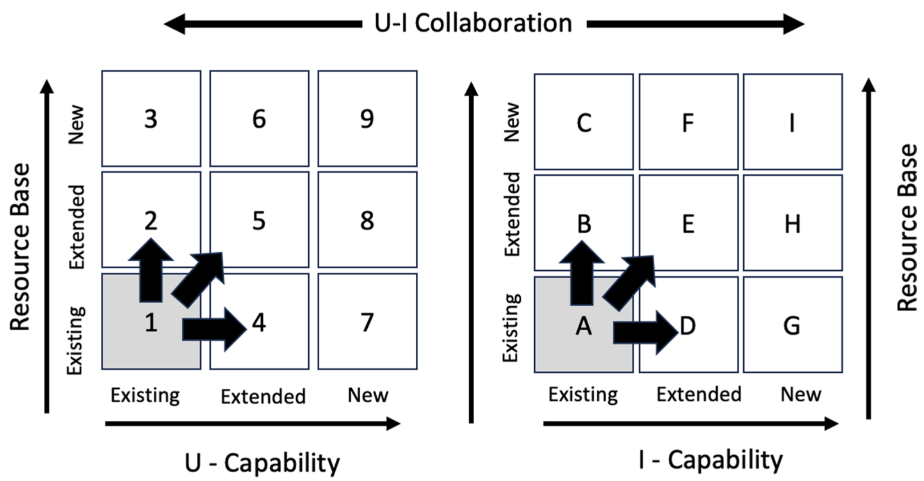


Fig. 1 University–industry knowledge and impact flow matrix

In the findings section the proposed matrix is more fully explained and then applied, and its use does appear to fit well with knowledge-intensive and impact environments, which can be challenging to assess according to Froehle and White (2014). Moreover, Voss (2005) recommends that this type of approach can be very useful for theory testing. Therefore, in proposing the assessment of the value and impact of knowledge transfer, we examine the knowledge transfer project (KTP) mechanisms and implications (Lang et al., 2014). A contribution of this research is therefore an evidence-based methodology that examines, assesses and maps impact. We believe this is potentially of great interest to industry, universities and the UK Government regarding their policy funding of U–I collaborations.

4 Findings

Table 2 presents the 13 U–I collaboration companies' products / sector, their operations project focus, and operations-based improvement. The first seven of the projects (C1–C7) are manufacturing and the remaining six (C8–C13) are healthcare. Eisenhardt and Graebner (2007) encouraged the use of such case evidence and the richness of data it provides.

As shown, there was commonality in the operational improvements and focus of the projects, with increased operational efficiency, operations strategy and the use of new operations planning/control technology, process improvements, and supply chain issues being common across the sectors. These were also in line with the expertise of the academic team involved. The projects themselves will now be discussed according to their sector: manufacturing and healthcare.

4.1 Manufacturing cases C1–C7

Aspects of the companies' products and strategies, future growth objectives and span of activities in developing new products, processes and services were examined, as shown in Table 3. This highlights the effects of being involved in these projects for both the company and the academic institution, which are discussed further in Sect. 4.3 below.

4.2 Healthcare cases C8–C13

A review of the healthcare cases was carried out in a similar fashion to the manufacturing cases with each organisation's new or improved capabilities collated as shown in Table 4. The healthcare organisations were non-profit making; impact was recorded in terms of cost savings, increasing/freeing up capacity, etc. In contrast to the manufacturing cases, not all health organisations needed to invest heavily to secure the long-term return on investment for these projects. The impact to the academic partner from the healthcare cases also differs significantly from the manufacturing cases, with all the projects producing academic publications, case studies and teaching material.

4.3 Impact perception

The developed University-Industry Knowledge Flow Matrix (Fig. 1) shows that there are a number of transitions a company can undergo from the starting position. According to Reed et al. (2021), it is challenging but possible to design an evaluation looking for causal

Table 2 Company profiles and their anticipated area for operations improvement

	Sector/Grant	Operations Project Focus	Operations-based improvement
C1	Manufacturing (Pharma) £66,917	Integrated operations enterprise & web-based Supply Chain Management	Operational efficiency Use of new operations planning/control technology Operations-marketing integration Effective use of people New IT equipment Operations strategy Product redesign Operations and process improvement New process technology
C2	Manufacturing (Food) £73,573	Operational Six Sigma methods to drive a cultural change	
C3	Manufacturing (Oil and Gas) £65,453	Operations-linked IT strategy	
C4	Manufacturing (ICT) £41,037	Integrate operations business systems	
C5	Manufacturing (Automotive) £63,423	Operations IT strategy	
C6	Architectural/design (IT) £64,333	Business intelligence operations system	
C7	Manufacturing (Food) £44,300	Process improvement: introducing new machinery & operations processes	

Table 2 (continued)

	Sector/Grant	Operations Project Focus	Operations-based improvement
C8	Healthcare (Commissioning) £75,692	Improve operational logistical assets	Process improvements Operational efficiency Use of new logistics planning/control technology New planning/control technology Operations strategy Service system redesign Effective human resource utilisation
C9	Healthcare (Provider) £66,329	Supply Chain Management healthcare services—patient-blamed non-attendance at outpatient clinics	
C10	Healthcare (Emergency Department) £129,761	Operational bed utilisation & utilisation in Emergency Department / Room services	
C11	Healthcare (Provider) £65,092	Operational improvement & management of the patient transport service	
C12	Healthcare (Commissioning) £61,486	Operations management planning process	
C13	Healthcare (Provider) £62,475	Operational new premises development & service integration	

Table 3 Manufacturing industry–university summaries

	C1	C2	C3	C4	C5	C6	C7
New/Improved Capabilities	Reduced processing times: Purchase orders Increased capacity order, Processing order tracking CRM Management	Reduced Staffing levels Stock control Lean thinking tools Six Sigma techniques	Strategic overview Project capability IT awareness	25% UK Market share Integrated business system Lower cost of sales Reduced inventory, Improved Quality Control, Reduction in purchase order costs	Reduced processing times: Stock controlling Increased capacity order Communication systems	Integrated marketing MIS system Open collaboration Confidence in MIS analytics Target markets	Reduction in raw material Reduced operating costs Factory waste
Cost Savings	£10 K IT Errors £2.5 K Transactions £4.5 K from online £7.5 K Tracking £3 K -Telecom	Y1 £300 K Y2 £330 K Y3 £380 K	Increased turnover 50% £50 K operating costs £75 K predicted on future projects	£430 K move from US market	Market share £250 K New market £250 K E-shop- £80 K Maintaining profit £200 K, with 9 less staff	£120 K New orders £10 K Billing time £20 K Admin support £30 K CRM (Conversation rate tenders 1 in 8-Target 1 in 25) Order winning 1in 4, previously 1 in 10	£80 K factory waste
Impact of cost savings	70% Growth Annual increase £989 K	5% increase profit on £20 M turnover	£500 K Pre-tax profit £1.4 M	£450 K of new orders 11% of orders taken £16 K on staff	70% Growth Annual increase £989 K	Y1 £170 K Y2 £200 k Y3 £230 K	0.3% i.e. 0.1% a year (£48 k), improved efficiency on line 1, i.e. increase throughput by 2% (£140 K)

Table 3 (continued)

	C1	C2	C3	C4	C5	C6	C7
Investments	Extranet Plant M/c £120 K New staff:3 Travel expenses £75 K	Extranet Plant M/c £60 K Shop floor IT system £70 K £2.5 M Expansion	4 New staff £40 K IT equipment Service offerings- adoption of digital formats	IT Servers £15 K Software £60 K Staff training £4.5 K	IT £120 K Office change £20 K New warehouse £80 K 15% Staff reduction £50 K Telecoms	New staff Marketing and IT Companywide MIS training (110) Servers and licenses £5 K	Recipe Weighing System (2008) Associated 30 staff training All staff on National Vocational Qualification 'Lean Manufacturing course'
Staff Development	Marketing strategy	Leadership development Business process Reengineering and Change management	IT training	Knowledge Transfer Project Champion Guest lectures	Case study Material for the academic Institution Staff development and recruitment	B2B Marketing, Bid Preparation, Key account management training – and branding	Documented change management paper Second Knowledge Transfer project awarded
Impact of Institutional Teaching	3 publications 1 UG project	2 int. publications Case study material	2 publications Case study material	1 conference publication Case study material	1 conference publication Case study material Enterprise modelling E-shop	B2B Marketing module Material for CRM 2 Case studies material	3 publications 1 UG project
Impact on University	Student visits Staff attending courses	Staff attending NLA course	2 Placement students 5 Staff attending courses	Employment of 2 graduates	Student visits Staff attending courses	Student visits. Staff attending courses	Student visits. Staff attending courses
Dissemination of Results	Marketing material – Regional impact case	Marketing material – Enterprise network	Marketing material – Enterprise network	Marketing material – Regional impact case	Marketing material – Enterprise network	Marketing material – Regional impact case	Web story on university portal

Table 4 Healthcare industry–university summaries

	C8	C9	C10	C11	C12	C13
New/Improved Capabilities	Transport Legal issues Resourcing for demographics Service support Training Patient knowledge Staff knowledge	Resourcing for demographics Service support Training Patient knowledge Staff knowledge	Resourcing for demographics Service support Training Patient knowledge Staff knowledge	Resourcing for demographics Service support Training Patient knowledge Staff knowledge	Service support Training Staff knowledge	Resourcing for demographics Service support Training Patient knowledge Staff knowledge
Cost Savings	£84 K plus £8 K recurrent: reduction in appropriate transport use £168 K recurrent: set up of pathology transport service	£250 K recurrent: DNA reduction £400 K recurrent: Reduced hospital caused cancellations £273 K Reduced waiting lists	£5.8 M recurrent: Bed day reduction, Expanded Medical Admissions Unit, surgical bed reduction, Delayed discharges decrease, Radiology £890 K reduced ultrasound wait	£123 K recurrent: Reduced cost of the contract £206 K recurrent: Reduction in ad hoc journeys, £124 K recurrent: Reorganisation patient dialysis sessions	N/A	£357 K recurrent: Reduction in time to complete the development of new premises

Table 4 (continued)

	C8	C9	C10	C11	C12	C13
Impact of cost savings	96% patients would not have attended the appointment if transport had not been provided 36% increase in screening uptake 14% patients screened have been referred for further tests 29% have background retinopathy The partnership has strengthened the engagement of all the key stakeholders	Reduction in cancelled appointments Reduction in the number of patients that get more than 1 follow-up appointment Implementation of Balanced Scorecard performance measurement system for the Outpatient Department	1,300 bed days p.a. saved in the Medical Assessment Unit 43,476 bed days p.a. saved through reducing length of stay for emergency patients Increased elective surgery capacity by 1,021 admissions p.a Increased organisational capability to hit key performance objectives	Reduced risk to the patient from spending fewer nights in hospital Improved use of resources Reduced length of stay, therefore bed available for other patients	Strategic meeting relevance increased from 35 to 90% Development of Balanced Scorecard for strategy deployment Virtual library was created for articles on developing strategy	The following cost savings are being achieved: Implementation of the design Lean Methodology: Consultation cost -10% Business case cost -5% Optimisation of Decisions -10% Opportunity cost -2% Full business case cost -5% Design cost -10% Long lead time cost -3% Construction cost -5% Rework design cost -5% Energy cost -10% Resource utilisation -15% Maintenance cost -10%
Investments	£12,000 in the development and implementation of a new expense system Head of Logistics and Transport Contracts post created	There will be investments in information systems to integrate the Balanced Scorecard into existing systems	New Medical Assessment Unit 2 Staff to run the new bed capacity management system 1 Speech Therapist post created	Transport coordinator post created	N/A	N/A

Table 4 (continued)

	C8	C9	C10	C11	C12	C13
Staff Development	Training will be delivered to all staff on the new expenses systems	Staff have been trained in the use of data gathering and analysis tools and process mapping, the use of the Balanced Scorecard	Staff have been trained in the use of data gathering and analysis tools and process mapping	Staff training in order to support the roll out of the new service and improve standardisation and clarity in the transport booking process	Staff have been trained in the use of data gathering and analysis tools and process mapping, the use of the Balanced Scorecard	Training in business improvement tools and techniques: MCDA, QFD, Benchmarking, Performance measurement, Lean techniques
Impact of institutional Teaching	3 academic journal publications 2 conference publications Case study material	2 academic journal publications 2 conference publications Case study material	2 academic journal publications Case study material	2 conference publications Case study material	1 academic journal publication 2 conference publications Case study material	2 int. publications 3 conference publications Case study material
Impact on University	Guest lectures	Guest lectures Associate-led weekly seminars	Associate-led weekly seminars	Associate-led weekly seminars	Guest lectures	Guest lectures Staff attending courses
Dissemination of Results	Teaching material Associate awarded "Business Leader of Tomorrow" by Technology Strategy Board	Teaching material Presentation to local and national NHS	Teaching material Presentation to local and national NHS	Teaching material	Teaching material	Teaching material

links and measure indicators to gauge progress towards impact. To explain, we suggest that a company traditionally extends its resource base incrementally in regard to their expertise, as per Donovan and Hanney (2011) and the Payback Framework, which organises measurement of impact across seven stages and two interfaces, typically represented in a research cycle. For example, this can be demonstrated by moving from cell A to B or C accordingly within the boundaries of the company. This will include perspectives on cost and operational efficiencies, as explained in Sect. 3.2 in the methodology section, and as discussed by Richards and Panfil (2011) in their work on cost effective social impact. Extending the position of the company from cell A to cell F (see Fig. 2) potentially involves a higher level of risk and investment in order to capitalise on new opportunities. In this regard, a knowledge transfer intervention is more calculated with a shift in emphasis regarding control, monitoring and review in order to realise a strategic intent, which fits with Perkmann et al.'s (2021) reporting that results of impact are improved when academics initiate projects, as opposed to reacting to requests. A U–I strategy is represented in Fig. 2 by a 'Knowledge and Impact Flow' from the university, cell 5 (the left-hand 3 × 3 matrix representing the university research impact) to the Industry Partner cell A (the right-hand 3 × 3 matrix which demonstrates initial introduction to the company). During the continuation of the partnership, the university and industry partner work together to achieve a shift from cell A to cell F. These shifts are critical in terms of risk due to the embedding of new knowledge and methods (Reed et al., 2021), and the co-creation project interface which offers the industry partner an opportunity to fundamentally change their processes/product and service offerings in an evidence-based controlled manner (Lee & Miozzo, 2019) and plan for the sustainability of the knowledge transfer (Huguenin & Jeannerat, 2017).

The university can be seen to have gained from the experience via the perception of movement from cell 5 to cell 9, demonstrating increased know-how and applied knowledge of application in a specific context (Hawkins et al., 2015). However, the focus of our paper here is on the impact created for the industry partners, so we prioritised the insights sought regarding the industry adoption and outcomes, not the benefits to the university partners. Within this overall process it is critical to identify at an early stage the perceived knowledge gap (Cassiman et al., 2018). For example, the shift from cell 5 to cell A could

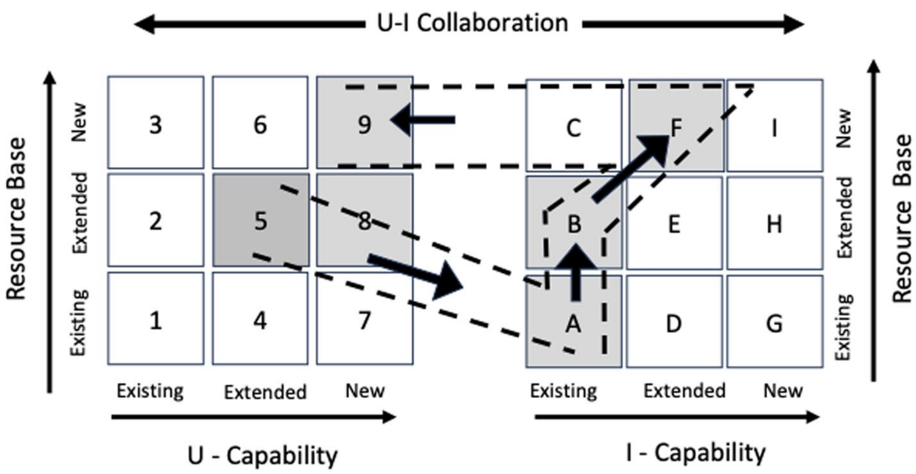


Fig. 2 Knowledge and impact flow matrix

be relatively straightforward, however moving from cell A to cell F, then cell F to cell 9 will involve partnering, co-creation, extensive intervention and a high level of project interdependency, plus it is essential that external project partners are also responsive and flexible in order to gain the maximum impact for both the industry partner and the university (Bahemia et al., 2018).

To provide clear focus on the difference that the collaboration has made to industry (and due to word count restrictions), in this paper the developed Knowledge and Impact Flow Matrix is being represented from the industry partner perspective.

4.3.1 A worked example

As a specific illustration, let us take manufacturing company C1. Following the methodology described in Sect. 3.3, C1 was placed on the horizontal Increased Capability axis in cell B at position 4 of 10 (MB4), and on the vertical Resource Base axis at cell B at position 0 of 10 (RB0). From there the developed perception of the project team was that a shift was achieved to the horizontal Increased Capability axis in cell E at position 1 of 10 (ME1), and on the vertical Resource Base axis in cell E at position 0 of 10 (RE0). The results of this assessment for the 13 projects are fully detailed in the sections below.

4.4 Knowledge and impact flow matrix application for the industry partners

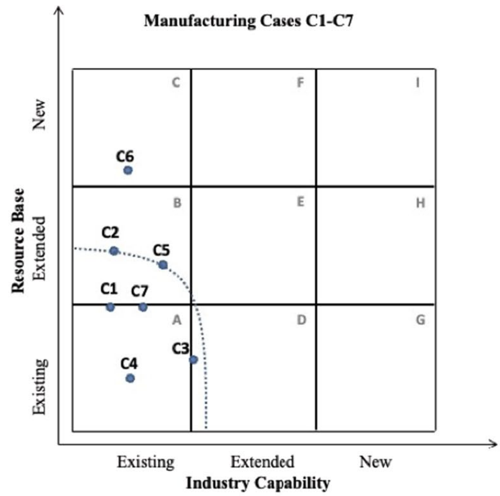
The authors and project teams have taken the data for the industry partners from the findings and plotted them on a Framework of U–I collaboration. Figure 3 shows a representation of the manufacturing organisations positioning and Fig. 4 shows the same for the healthcare cases. Each has a representation of the knowledge and impact flow matrix, with the specific scores below each graph. The matrix on the top shows the positions as defined by interpretation of the Key Sources of Information (in Table 1) and the project teams before the two-year knowledge transfer projects started. A line of best fit (the dotted line) was agreed by the project stakeholders and applied to represent the trend of the data.

Taking the idea of applying the Knowledge and Impact Flow Matrix further, the bottom matrix in Figs. 3 and 4 shows a representation of the organisations' position after the two-year knowledge transfer project, again as defined by the project teams' interpretation. The dotted line (line of best fit) on the right demonstrates this visually. This representation identifies the evidence-based perception of knowledge transfer with the organisations (Akinc & Meredith, 2015; Al-Faraj et al., 1993; Forker & Mendez, 2001), indicating the perceived greater impact reported within the healthcare cases.

5 Discussion

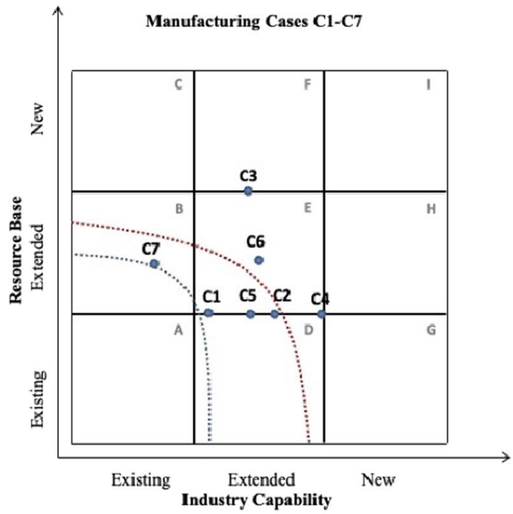
5.1 Mechanisms by which impact is achieved

Before discussing the findings of the research in relation to the research questions, it is helpful to explore the impact of U–I knowledge transfer using an Input-Transformation-Output framework (Bamford, Forrester and Reid, 2023) as per the representation in Table 5. This collation and presentation of activities enables us to better comprehend impact at multiple levels, especially through the knowledge transfer process phases and through time. Wu et al. (2021) identified the many complex aspects to assessing



Manufacturing Cases	C1	C2	C3	C4	C5	C6	C7
*Initial Position	IB4,RB0	IB4, RB5	ID0, RA6	IA5, RA5	IB8, RB4	IC5, RC1	IB6, RB0

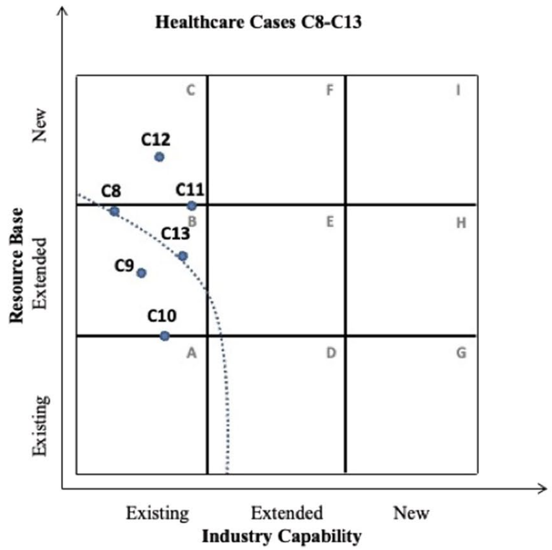
*Note - Cases' position represented considering the Industry Capability (I) axis first then the Resource Base (R) axis, e.g. (I,R)



Manufacturing Cases	C1	C2	C3	C4	C5	C6	C7
Post Project Position	IE1,RE0	IE6,RE0	IF4,RF0	IH0,RH0	IE4,RE0	IE5,RE5	IB7, RB4

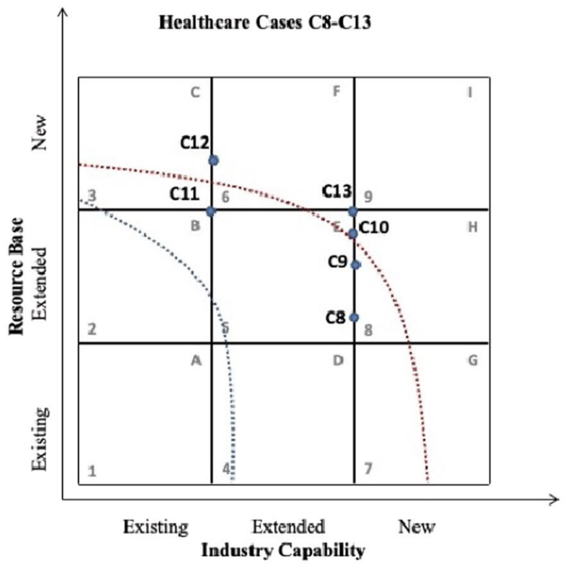
Fig. 3 Framework of U–I collaboration—Manufacturing cases

collaboration impact and proposed a fuzzy synthetic evaluation method. Whilst there is no doubting the potential of such an approach, especially with the creation of identified mechanisms of knowledge service transfer, it does have a disadvantage of being extremely complex.



Healthcare Cases	C8	C9	C10	C11	C12	C13
*Initial Position	IB3,RB10	IB5,RB5	IB7,RB0	IC9,RC0	IC7,RC4	IB8,RB7

*Note - Cases' position represented considering the Industry Capability (I) axis first then the Resource Base (R) axis, e.g. (I,R)



Healthcare Cases	C8	C9	C10	C11	C12	C13
Post Project Position	IH0,RH2	IH0,RH6	IH0,RH9	IF0,RF0	IF0,RF4	II0,RI0

Fig. 4 Framework of U–I collaboration—Healthcare cases

Table 5 Mechanisms for university–industry collaboration

CONTROLS
Time/Quality/Cost

Input	Transformation	Output
Industry partner willing to engage/change	Industry partner willing to engage and change	Embed change in a sustainable manner
University partner with interest/expertise/capacity to engage	Recognize the impact will take time – at least 12/24 months	Communicate regularly and effectively to all stakeholders
Define strategic problems/opportunity	Constructive & facilitated team working throughout	Disseminate what done and how achieved
Dedicated resource/team to be appointed (however small)	Drive to generate accurate current state metrics/data as a baseline	Do not feel the end of the project is end of improvement – plan to push forward
Agreed project plan (initial)	Drive for using academic theory/cases as evidence base for inspiration/catalyst regarding new processes/methods/etc	Record and share tangible ongoing improvements
Appropriate budget	Resilient project management throughout	Celebrate ongoing successes – praise people and teams
Ability to predict the market in the short term (6–12–24 months)	Using appropriate measures/metric/data to track actions/progress	Consider the next project
	Document gains/wins	
	Document areas for improvement	
	Celebrate successes – praise people and teams	

————————————-RESOURCES————————————
Knowledge capital / Staff / Infrastructure / Processes and procedures / Innovation / Suppliers / Services / Materials

Table 5—Mechanisms for U–I collaboration, summarises the critical issues and activities identified during the research that are considered essential to facilitate the transfer process (before, during and after). In addition, the thinking underlying the project management Iron Triangle (Carvalho & Rabechini Junior, 2015) of time/quality/cost trade-offs was recognised as being most useful as it is simple, easily understood and appears applicable to context. Additionally, it was recognised that the resources available before, during and after will have an impact on the degree of collaboration results achieved. These resources are most typically around the aspects identified by Dale, Bamford, and van der Wiele (2016) as knowledge capital, staff, infrastructure, processes and procedures, innovation, suppliers, services and materials. Whilst there is no doubt that the mechanisms identified in each of the columns (input/transformation/output) could be taken further, they do provide experiential insight to mechanisms of U–I collaboration.

5.2 How to evidence and capture the impact generated by U–I knowledge transfer projects? (Research Question 1)

Lang et al. (2014) suggest that there is an optimal extent of knowledge transfer, so as per Sect. 2.1 we created a Knowledge and Impact Flow Matrix (Fig. 1) to examine impact in an objective manner. This matrix implies that the knowledge and impact are interdependent and interdetermining and the capability assessment was performed across a number of factors. For example, product, process, people, operations and organisation with respect to the above critical factors, and for each a set of measures were identified that addressed the requirements of the project. This answers the call for research impact evaluations to draw on mixed method approaches, triangulating evidence from multiple sources (Reed et al., 2021).

As identified in the literature (Aalbers et al., 2014; Binder & Clegg, 2006; Cohen & Levinthal, 1990; Mom et al., 2015; Radaelli et al., 2014), diverse firms and organisations have different levels of experience in innovation and multiple levels of absorptive capacity (Argote & Hora, 2017; Lawson & Potter, 2012; Nagati & Rebolledo, 2013; Saad et al., 2017). They also have differing needs for relationship working, and these are likely to vary significantly between healthcare and manufacturing; this is detailed in the literature between public and private sectors (Al-Faraj et al., 1993; Gaimon et al., 2017; Liu et al., 2014).

Interestingly, Dooley et al. (2013) state specifically that knowledge transfer requires lengthy, direct and intense interactions; therefore, the policy of set-up and nature of the two-year projects provide an appropriate sample to assess the results and impact. This we sought to examine using the Reed et al.'s (2021) definition of research impact as the demonstratable, perceptible benefits to individuals, groups, organisations and society that are causally linked to research. Each project was therefore assessed in terms of the perceived step change with reference to the Knowledge and Impact Flow Matrix from Fig. 1. As evidenced by the collation and assessment of the 13 U–I collaborations presented in this paper, it is possible to evidence manufacturing and healthcare organisations generating impact and improvement—but our research goes beyond that by examining the difference between two sectors, making a contribution to the field. These findings relate to the work of Bhattacharjee and Chakrabarti (2015), Binder and Clegg (2006), Ferdows (2006), Ram et al. (2014), Reed et al. (2021), Soloducho-Pelc (2014) and Su et al. (2014), who all mention aspects of impact regarding new business practices and partnerships, processes and products, as well as estimating the return on investment. In addition, as per Radaelli et al. (2014), under the right circumstances universities can substantially help firms as they endeavour to develop their competitive advantage by supporting them in applying novel systems, products and processes (Audretsch et al., 2014; Wright, 2014). Seno Wulung et al. (2018) identified that the technological distance between collaborators could be a direct factor of influence, another area where universities would add value to the relationship. Arthur (2010) positions this well by describing the opportunity as one of offering fresh insights and perspectives, a view reinforced by Alexander and Childe (2013), Gaimon et al. (2017), Gertner et al. (2011) and Perkmann et al. (2011). They highlighted the benefits of building wider networks, the training/adoption of new techniques, methods and approaches, and particularly the practical value of research by embedding research outputs directly into the real business world. Pawar and Rogers (2014) observe that firms apply a range of knowledge transfer mechanisms and approaches, perhaps to aid the planning cycle and to try and enhance their degree of control. Pérez-Salazar et al. (2019), in their review of supply chain research, identified that knowledge transfer was discussed by the majority of the studies they evaluated. Argote and Hora (2017) promote three components (members, tasks, tools). These results perhaps demonstrate what Lowe and Locke (2006) and Steuer et al. (2011) define as movement towards the 'competitive edge' (Akinc & Meredith, 2015).

Finally, the results discussed above support the Joglekar et al. (2016) perspective that industry studies provide a uniquely valuable platform for studying the implications of and potentially prescriptions for public policy initiatives. As such, a contribution of this paper is a methodology to provide tangible proof for policy makers of impact, combining both quantitative and qualitative data, regarding the UK Government policy of funding Knowledge Transfer Partnerships.

5.3 What are the differences in impact between manufacturing (private sector) and healthcare (UK public sector) U–I partnership projects?

(Research Question 2)

This section will address the question from a number of perspectives, inspired by Anderson et al. (2007) preposition that there are no differences in university technology transfer efficiency between public and private institutes. In Figs. 3 and 4 it is noted that there are significant differences between the degree of impact generated when comparing the sectors. Each U–I connectivity does not appear to have benefited equally from the knowledge transfer project. This could be, according to the literature (Boer et al., 2001; Fox et al., 2013; Li et al., 2012), a reflection of the company maturity, attitude to risk taking, management style and willingness to contemplate radically altering processes and service offering, as well as its openness to challenge the status-quo; as Reed et al. (2021) suggest, it can be a highly subjective process.

Comparing the manufacturing with healthcare U–I collaboration shows that improvement and impact appear more pronounced with the latter as shown in Fig. 4. The manufacturing organisations were, at the start, reasonable at managing their processes and operations compared to the healthcare organisations, but in theory the room for impact should be similar. Their perception was that they had to apply any new methods and skills transferred in a more 'commercial environment' (Maldonado-Guzmán et al., 2016) when compared to healthcare. Manufacturing firms that have survived over the past decades (post-2008 recession, Brexit, covid-19) have had to rapidly improve processes and efficiency or they would have failed. This is different for healthcare organisations as they operate within the public sector. This appears to fit with the arguments by Bessant et al. (2003) whose research explored the possibilities of transferring appropriate practice during uncertain and turbulent conditions. In healthcare the use of management techniques and technologies that are considered standard in manufacturing (such as lean, six sigma, benchmarking, multiple criteria decision analysis) are still very innovative (Bamford et al., 2015; Dehe & Bamford, 2015, 2017; Papalexi et al., 2016), so there exists the potential for even greater impact and critical contribution (Liu et al., 2014). Additionally, Bruneel et al. (2010) did identify that prior experience of collaborative research lowers orientation-related barriers. Interestingly, these results do appear to fit with the more pronounced knowledge transfer 'know-how' as evidenced for the healthcare organisations in Fig. 4. This phenomenon was tangibly demonstrated by the results of these partnerships, where knowledge is perceived as a key driver of creativity and improvement (Gaimon & Bailey, 2013). We therefore propose that within our sample of organisations, the healthcare companies demonstrated higher absorptive capacities than manufacturing, which fits with the suggestions of some authors (Argote & Hora, 2017; Lawson & Potter, 2012; Nagati & Rebolledo, 2013) that organisations have different levels of experience in innovation and multiple levels of absorptive capacity.

We also note that the healthcare organisations sought longer-term benefits and impact from the partnerships than their manufacturing counterparts, who were keener to acquire short-term gains in productivity. This could be due to the prevailing cultures associated with the public sector (serving the needs of the public, Canel & Luoma-aho, 2018) and the private sector (serving the needs of shareholders/immediate stakeholders, Konzelmann et al., 2020). Moreover, we notice that the healthcare projects generated significantly more academic outputs than manufacturing (healthcare projects 21/6 = 3.5 journal and conference articles per project compared to 12/7 = 1.7 for the manufacturing projects). When examined, this was explained by a greater sense of openness and willingness to promote, share and disseminate the findings within the healthcare community. Of course, this needs to be moderated by a greater need for confidentiality in the manufacturing sector to avoid exposing potentially sensitive information, or as one company put it, 'giving away competitive advantage'. Hence, whereas proactive dissemination outside the organisation was actively promoted within the healthcare projects, it was not as evident within manufacturing.

6 Conclusions

U–I partnerships are well established and there appears to be evidence of its positive contribution to knowledge-based economies, industry, and society (De Silva et al., 2021; Perkmann et al., 2021). However, evaluating, assessing, and measuring the actual impact of U–I collaboration has been rather challenging to date (Maguire, 2012; Reed et al., 2021). Responding to this call, this empirical research develops a framework to assess the effect of U–I collaboration, considering both the theoretical and practical issues of knowledge transfer and most importantly the impact of the longitudinal U–I engagement. Impact has been defined as the 'increased capability' (e.g. adopting new business practices, generating innovative processes and products, developing competitive advantage, etc.), perceived as both tangible and intangible, objective and subjective, and evaluated using a varied source of data (Reed et al., 2021). This study develops further the work of Alexander and Childe (2013) and Siegel et al. (2004) who discussed the need for a growth in university technology and knowledge transfer and associated management and policy implications. U–I collaboration has been explored based on the concept where one party is commercially or operationally improvement driven, whilst the other is driven in terms of research impact. For organisations, this is very useful as we have reinforced what Kent and Siemsen (2018) suggested, namely that learning happens at a much faster rate with the use of a policy template such as the U–I collaboration. An important note is that this model requires active facilitation throughout the partnership process, as part of the process of co-creation.

In terms of increasing the levels of confidence and predictability, and of reducing the risk that organisations expose themselves to, the analysis and resulting evidence base presented by this paper proves that U–I collaboration is capable of being assessed. That being the case, this paper directly answers the call by Joglekar et al. (2016) for further investigations and public policy research into operations within the healthcare and high-tech manufacturing industries and shows the potential for comparing one sector with another. It also provides proof of the effectiveness of collaborative partnerships templates for the UK Government policy and funding schemes and makes a strong case for the continuation of funding in this area.

As a contribution, the developed framework (Fig. 1) judges the impact of the knowledge and impact flow and should be of interest to practitioners in assessing the impact of U–I collaboration as well as the knowledge flow in terms of improving U–I connectivity and engagement. The identified mechanisms in Table 5 provide further illumination towards this, highlighting the requirement of an active facilitation before, during and after the project. Additionally, from a theoretical perspective, our paper takes forward the work of Bhattacharjee and Chakrabarti (2015), Binder and Clegg (2006), Ferdows (2006), Ram et al. (2014), Reed et al. (2021), Soloducho-Pelc (2014) and Su et al. (2014), and supports the Joglekar et al. (2016) viewpoint on industry studies.

However, there do exist a number of unanswered / unexplored areas that, given word limitations and the need for a defined focus to this paper, are perhaps more appropriate for future papers and research focus: (i) the impact (Reed et al., 2021; Upton et al., 2014) that universities are actually capable of regards connectivity and impact needs to be more fully explored, especially with regards Business Schools and non-science based projects; (ii) the concept of 'additionality', taken from the worlds of economics / financial accounting (Marino et al., 2016) and meaning what has actually been achieved 'in addition' to what would have been done anyway. Investigating aspects of additionality, the level of analysis would require far more rigorous monitoring pre / during / post project and was outside the scope of this paper; (iii) the finding that healthcare appeared to benefit more than the manufacturing perhaps indicates that further work is necessary to explore the issues limiting the productivity and impact of manufacturing–university partnerships; and finally, iv) it is worth investigating further the dual relationship between impact as a capability enabler, and organisational retention. To explore the links with the concept of organisational memory (c.f. Moorman & Miner, 1998) and also the implications of routines in task driven environments (Yi et al., 2016).

Appendix

See Fig. 5.

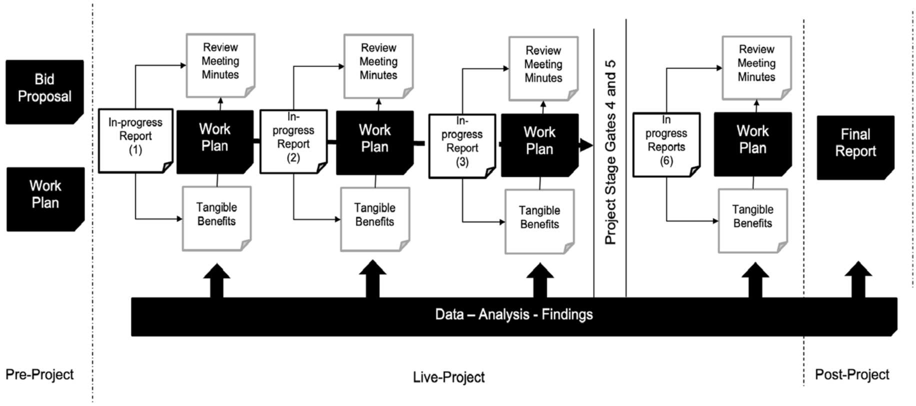


Fig. 5 Artefact timeline

Acknowledgements The authors would like to acknowledge the 13 case organisations for the sheer support during these projects. The authors are grateful for the insightful feedback received from the journal's editor and reviewers.

Funding No funding was received for conducting this study.

Declarations

Competing interests The authors have no competing interests to declare that are relevant to the content of this article.

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