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# Managing University-Industry Research Partnerships through a Process of Alignment

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*Abstract*--**University-industry research partnerships provide a mechanism for enhanced knowledge transfer thereby contributing to improved technology development within industry as well as providing a secure source of research funding at universities. However, misalignment of objectives, difficulties in the negotiation of research contracts, and challenges arising from research co-ordination are just some of the issues that can be encountered. Therefore, following a review of the literature a management framework has been developed to help practitioners manage these issues. The framework is based on the need for alignment in three core areas, namely technical, commercial and social. The alignment mechanism will be explored through case study investigations of three research partnerships, which included two successful partnerships and one that encountered difficulties. The case studies will be compared and contrasted to help identify management strategies and supporting activities that can be undertaken to underpin the development and subsequent management of university-industry research partnerships. The findings include a need for clear leadership of partnerships including boundary spanning; robust commercial arrangements including the allocation of intellectual property rights; effective governance mechanisms and performance measurement; and the significance of companies' absorptive capacity.**

## I. INTRODUCTION

Companies from a range of industrial sectors collaborate with universities in order to gain access to research and technology as well as the resulting knowledge and analysis in order to improve the competitive positioning of the company [1, 2]. Such collaboration can be more common in so called knowledge-intensive industries, such as the pharmaceutical, aerospace and defence, oil and gas, and telecommunications sectors. Companies in these sectors have a major focus on sustaining technical innovation [3] and working with universities provides an important channel [4] to gain access to both creative thinking and knowledge that can ultimately be used to help companies develop and subsequently produce new or improved products or services. In this context universities collaborate with companies for a number of reasons [5] and this can be through contract research, consultancy or other means, such as via governmental funded schemes that are predicated on the need for industrial collaboration. Collaboration between universities and companies enables the commercial application and translation of fundamental research carried out at the university and it also provides the university with access to application-specific data and information so as to validate research findings, e.g. a chemical engineering academic group working with an energy company to test the design of a new fuel cell configuration. Finally universities work with companies to secure industrial funding for research workers (namely graduate students and post-doctoral researchers) as well as for new equipment and technical facilities. In this manner the development of research partnerships over a longer-term basis offers improved prospects for universities and companies to collaborate thereby providing enhanced benefits for both parties such as those described previously. Conversely, short-term contract research (e.g. involving a short piece of consultancy) placed at universities will likely be more transactional in nature focusing on, for example, the provision of vibrational analysis on the operation of a particular turbine blade configuration for an aerospace OEM (original equipment manufacturer).

When companies and universities work together on a specific research project, there needs to be a focus on meeting a particular industrial requirement [6] and a single project will likely be the most effective vehicle to provide value to the company, for example, through provision of data on the materials decomposition pathway for a new carbon fibre resin developed for an aerospace application. However, when the relationship between a university and company advances further, there will be advantages in developing a strategic partnership between the organisations through building on synergies to derive greater value for both parties. In the aforementioned aerospace example, additional benefits could involve the development by a joint university-industry team of an improved flight control surface that benefits from laminar flow modelling carried out at the university. This closer working would allow technical issues to be rapidly shared between industrialists and academic researchers thereby improving the translation of research to the company and the efficiencies of the collaboration process. Although such sharing would likely only take place once a close working relationship had developed, which can therefore be viewed as one of the features of an effective research partnership.

The subject of university-industry research collaboration has been explored from different viewpoints and there is much work in the literature on the subject [7, 8]. This includes, for example, studies of how this form of collaboration sits alongside industrial innovation and technology development in regional clusters such as Silicon Valley in California, USA [9] as well as studies that highlight how the impact of academic research on regional innovation (i.e. through so called knowledge spillover) is supported by the network effects of university-industry research collaborations [10]. However, there are continued challenges [11] associated with this form of joint working, and

especially as companies come under increasing financial pressure to innovate and remain competitive alongside other often global competitors. This pressure can translate through to relationships with universities; there can be an increased focus on the industrial benefits of the research and alignment with the company's objectives as well as a focus on the need for value for money returns from the research and a more short term focus. Moreover, the process through which companies work with universities can be considered through the 'open innovation lens' [12]. This intellectual framework emphasises how firms are able to harness additional routes to innovation through sourcing knowledge from external sources (such as universities and start-up companies) and not simply relying on R&D carried out within the company's laboratories (which would represent a closed innovation approach) [13].

Research-intensive universities in many countries (such as the US and across Europe) have been able to position themselves to meet this shifted requirement through carrying out research that is aligned to industrial requirements, e.g. through academic consultancy, contract research and also from the industrial sponsorship of students and researchers. However, there are challenges and certain complicating issues that may arise. There is a need for companies to manage external relationships and thereby manage across organisational boundaries that is implicit with the open innovation model. There can be difficulties associated with coordinating the academic outputs so that they remain focused on the industrial requirements, which can result from a misalignment of objectives from the outset of the interaction. Furthermore, there can be difficulties associated with the commercial arrangements that underpin collaborations between universities and companies and specifically how intellectual property (IP) is allocated and managed thereafter. This latter challenge can in some cases ultimately lead to collaborative agreements not being secured and collaborations failing even before they have commenced.

Consequently, this paper has been written in order to explore how these challenges and issues can be addressed effectively and efficiently. Specifically the focus of the work is on how university-industry research partnerships can be developed and subsequently managed to provide benefits and enhanced capabilities for the collaborating partners. Therefore, following a review of the literature on university-industry research collaboration, there will be examination of the factors that have the capacity to contribute to the performance of research partnerships between companies and universities. A management framework has been developed that builds on the literature findings and the framework has been investigated through case study investigations of three university-industry research partnerships from the United Kingdom. The case study findings will be analysed and contrasted followed by conclusions and future work.

## II. INDUSTRY SUPPORTED AND CONTRACT R&D TRENDS AT UNIVERSITIES

The level of industry financed R&D secured by universities in the United States has increased steadily over the last few decades (see Fig. 1), rising from $1.526Bn in 1989 to $2.988Bn in 2009 [14]. Moreover, within the United Kingdom, the level of contract research, comprising funding from large industrial businesses, SMEs (small and medium enterprises) and third-sector public organisations, has also increased in recent years (see Fig. 2), rising from £671M in 2003-04 to £1.05Bn in 2010-11 [15].

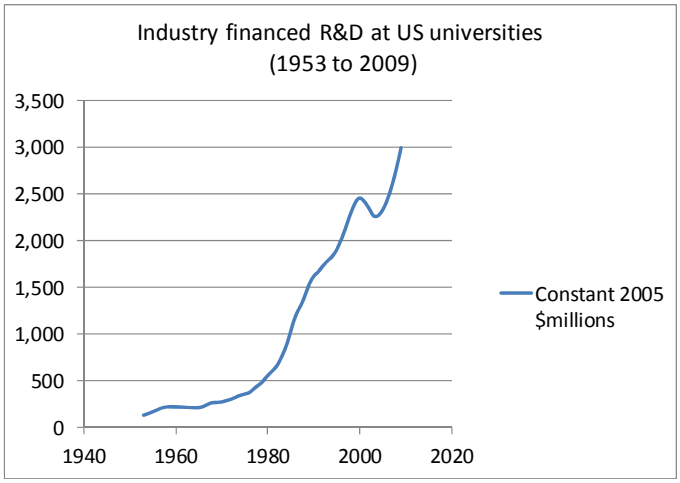


Fig. 1: Industry financed R&D at UK universities [14].

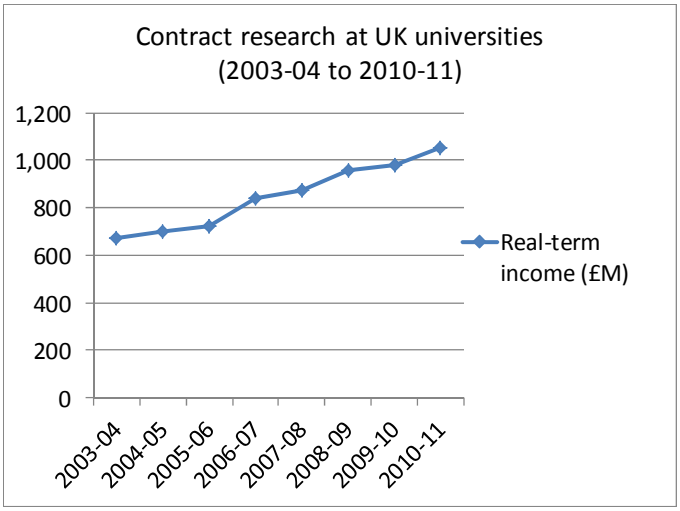


Fig. 2: Contract research at UK universities [15].

This data from the UK and USA suggests that in these two countries the funding of contract research including industry financed R&D is an important and growing part of the higher education landscape in addition to being an increasingly prominent part of the industrial innovation environment. As academic institutions, universities are of course principally

established to provide education at undergraduate and graduate levels and in the case of research-intensive universities this will extend to empirical and theoretical research across relevant academic disciplines. The structures and processes of such universities have been designed to support this mission. However, as the level of research translation through industry supported activities and contract services increases there will be a concomitant need to accommodate these activities alongside the core education and long-term research funded by governmental, charitable and philanthropic sources. Consequently this will drive the requirement for enhanced practices and processes underpinned by strategy developments to enable the university-industry interface to be efficiently managed. Across the academic arena, there are some universities that have flourished and there are others that have not been able to capitalise on the opportunities afforded with industry. The ability then to understand the supporting factors and processes that contribute to university-industry relationships is an important area for consideration by universities and by companies that intend to work with academia.

Returning to the data and in the case of US universities, it can be observed there has been a significant increase in the level of industrial funding from 1980 onwards. This can potentially be associated with the Bayh-Dole Act from that year, which gave US universities control of their inventions and associated intellectual property arising from federally funded research [16] although it should be noted there has since been several other pieces of legislation that have also made an impact in this arena [17]. Nevertheless having a supporting legislative environment can be viewed as being enabling in terms of university-industry interactions although technical and other commercial factors clearly also have a major bearing as well as the levels of interactions and network connectivity between academic institutions and industrial organisations.

In the case of UK universities, the types of translation activities associated with knowledge exchange (i.e. not classified as either education or fundamental research funded by governmental, charitable and philanthropic sources) can be categorised according to being either contract research, consultancy contracts, facilities and equipment services, CPD (continuing professional development) and IP income. It is interesting to note that in 2010-11 [15] the level of contract research (comprising funding from large industrial businesses, SMEs and third-sector public organisations) at UK universities was £1,050M, whereas funding from IP income was only £61M (see Fig. 3). Whilst IP income represents an attractive funding stream for universities that can often be unencumbered (i.e. it can be invested at the discretion of the university), it is useful to note its relative size (only 6%) when compared to contract research (including research funded directly by industrial companies). The ability to structure university and industry engagement to ensure knowledge translation is effective will therefore have a greater impact (in terms of financial scale) in the case of contract research when compared to IP income generation, and developing processes to support the development and management of research partnerships involving universities and companies can be viewed in this context.

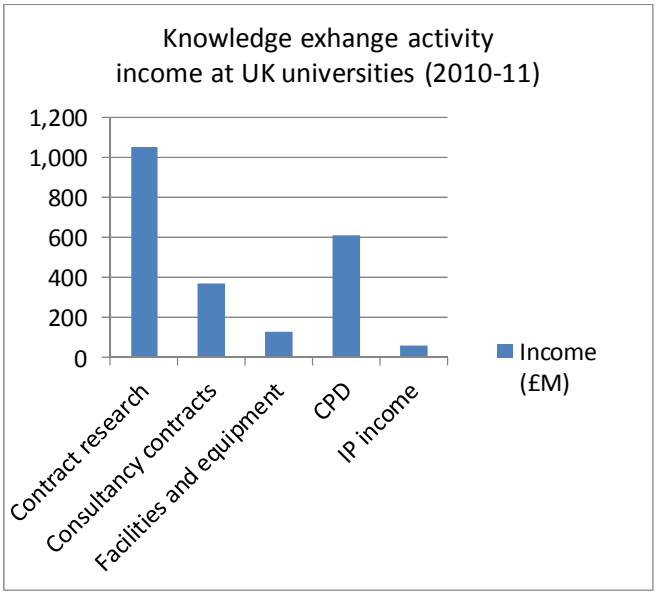


Fig. 3: Knowledge exchange activity income at UK universities [15].

Whilst it is useful to consider data on the level of industry financed research at universities, this only partly explains the complex situation that takes place in relation to the overall volume of activities involving universities and companies. Indeed there are a range of activities undertaken that can be associated with the interactions between universities and companies. At one end of the spectrum a company engineer may, for example, attend a technical seminar at a university, or there may be advice given on the direction of a masters' level degree programme through an industrial member that sits on an advisory board. Conversely, industrial companies have recently been involved in more innovative and much larger scale approaches to technology development with universities, such as through the co-location of industrial pharmaceutical scientists at university laboratories [18], or through participation in the European Knowledge Innovation Centres [19]. Consequently, developing an improved understanding of university-industry collaboration should take account of the variation of initiatives and how any particular configuration of collaborative activities will be contingent on the historical background, circumstances and future potential of any given collaboration.

## III. EXPLORING THE SUPPORTING FACTORS FOR UNIVERSITY-INDUSTRY RESEARCH PARTNERSHIPS

### *A. Commercial factors*

University-industry collaboration has been recognised as an enabler to support the commercial application of research

[20] that may have been previously funded by other means, such as through governmental, charitable or philanthropic channels. In regard to developing university-industry research partnerships and from the perspective of the company, there will likely be interest in enhancing the level of knowledge transfer to the firm. On this matter, Siegel et al. [21] have looked at the processes that support the technology transfer process between universities and companies. This research focused on the role of university technology transfer offices in facilitating the commercialisation of arising intellectual property (IP). The findings indicate how there needs to be flexibility and responsiveness when negotiating contractual agreements and especially in relation to clauses related to the allocation of IP rights (IPR). This responsiveness will need to be supported by the necessary culture and resources, which extends to the requirement for the university to employ relevant staff having been adequately trained to support academic faculty and allow commercial arrangements to be negotiated and finalised in a timely manner. An inability to achieve this goal can potentially result in university-industrial partnerships failing even before they have actually commenced. Furthermore, this work points to companies and universities having different perspectives on technology transfer as well as different motivations although financial compensation and knowledge benefits are clearly strong drivers. It is therefore a logical extension to assume that creating the conditions to support effective university-industry research partnerships can be associated with the need to secure alignment between universities and companies in the area of commercial practice and especially in regard to the allocation of IPR.

Through building on this thinking further, successful university-industry relationships can be subject to certain barriers [22], including orientation and transaction barriers. Orientation barriers are related to the often long-term view taken by universities involving say fundamental research being undertaken by doctoral students, which would need to be academically rigorous and sufficiently demanding to warrant inclusion in the student's doctoral thesis. Whereas companies may have a shorter-term view, which could be focused on deriving data, information and knowledge from the collaboration in order to enhance a product or service that is offered by the firm. Conversely, transaction barriers can be related to the potential absence of commercial staff at universities that have the expertise and experience to negotiate IP agreements. The ability to reduce these barriers and allow companies and universities to reach amicable positions through negotiating contractual agreements efficiently will therefore have a significant impact on the likelihood of a new research partnership being established and will also impact on the eventual success of the partnership.

Negotiation of university-industry research agreements has been shown to benefit from a joint team approach that is both consultative and structured [23], where an overall commercial model can be developed to support the negotiation of key terms and conditions (T&Cs) such as those relating to IP. Providing an adequate focus on this area at an early stage of a new partnership will therefore have a positive impact on the likelihood of an agreement being secured that meets the collaborating parties' expectations both in the shorter and longer timeframes. On this matter Liew et al. [24] have previously reported how establishing a clear commercial model can support the development of university-industry collaborations and this includes appointing a key representative, such as a dedicated project manager, to be responsible for the management of the collaborative partnership.

The process of developing a commercial model to support university-industry research partnerships needs to capture the requirements and relative priorities from both the companies' and universities' perspectives. This objective would be supported through the use of the framework in Fig. 4, which provides an illustrative example for the case of university collaboration with the pharmaceutical industry. The framework identifies the relative importance of the high-level requirements for research partnerships and more detailed analysis can be carried out on a particular area identified, such as the intellectual property rights (IPR) requirement. Further analysis could reveal, for example, that the pharmaceutical company is keen on gaining access on fair and reasonable terms to background and foreground IP arising from the research, whereas the university could be interested in owning IP but will allow commercial licensing with the company through favourable terms. Use of such a planning tool can therefore help to formulate the commercial arrangements of university-industry research partnerships and thereby structure commercial agreements to facilitate such partnerships.

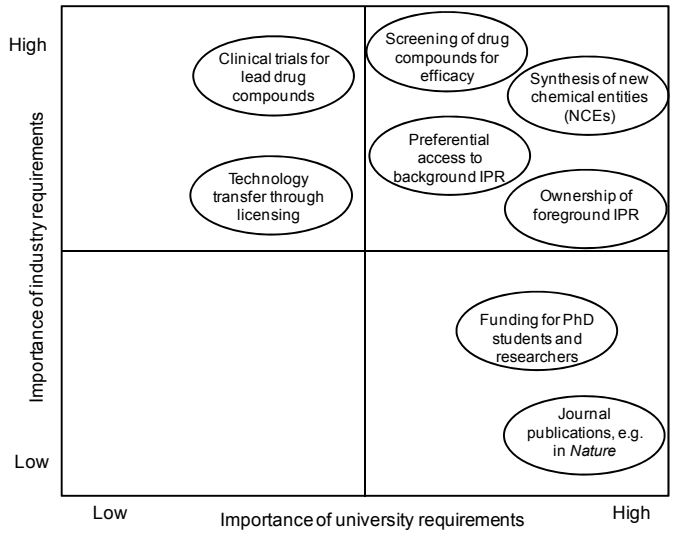


Fig. 4: Framework for analysing relative importance of industry and university requirements for research partnerships.

*B. Technical factors*

In addition to alignment of commercial interests, there is clearly the need for collaborating companies and universities to have common technical or academic interests, e.g. through alignment of the technical objectives for a research programme. Philbin [25] has evaluated how the use of structured methodologies can support the collaborative research process and this work emphasised how initial terrain mapping of the technical landscape allows research propositions to be developed and delivered thereafter. This research included a case study investigation of the aerospace industrial sector, where the capture of industrial requirements to support the definition of the research collaboration was influenced by governmental aerospace standards. Consequently, securing alignment of technical interests between companies and universities can in some cases be dependent on wider stakeholder interests such as those from governmental sources, which will also need to be considered for the collaboration process to be ultimately effective.

In terms of the matching of universities and firms, Carayol [26] found that firms often try to minimise risk when selecting a research partner whilst also maximising the potential commercial benefits for any arising technology. Therefore, proximity between academic research interests and the industrial requirements for research has the capacity to improve the prospects for research partnerships. Consequently, it can be observed that universities will tend to focus on fundamental research, i.e. relating to a low technology readiness level or TRL [27], whereas companies will tend to be driven by the availability of technology with a higher TRL. This mismatch in TRLs therefore has the capacity to weaken synergies between universities and companies and the ability to understand such potential differences at an early stage is important. Capturing these differences early in the partnership lifecycle would allow projects to be designed that can be academically rigorous whilst still fitting within an overall strategy to generate technical outputs that can be utilised by industry. Such planning can be captured through the use of technology roadmapping [28], which is a useful mechanism to support technical planning and it can also provide a graphical view of how research areas are developed over a given timeframe.

An example technology roadmap is provided in Fig. 5, which details the overall research strategy over an 8-year period to meet an industrial requirement for high-performance engineering nozzles that can be developed for production in a cost-effective manner. In this case, identifying the industrial requirements allows the supporting research projects to be determined, which are in turn underpinned by research objectives. Development of such a technology roadmap would allow potential collaborators to identify key research areas and technical synergies, thereby driving alignment of both academic research interests and industrial technology interests.

*C. Social factors*

The level of success for collaborations between universities and companies has been shown to be related to the extent of existing interactions between partners (i.e. interactions pre-dating the collaboration), which highlights the positive and significant impact that social and network connectivity can have on such collaborations [29]. In other work cultural differences between universities and companies have been shown to effectively lead to barriers that prevent collaborations being successful [30] but Bjeerregaard [31] has proposed that such barriers have been diminishing in recent periods. This research points to universities that have

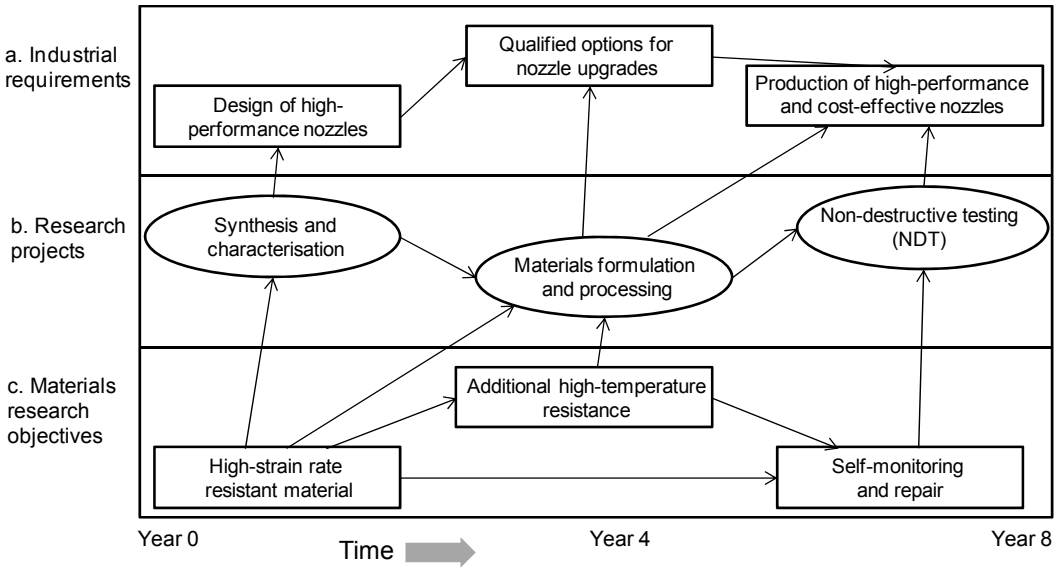


Fig. 5: Technology roadmap to support research and technology planning for engineering nozzle application.

increasingly institutionalised commercial best practice, such as through appropriate staffing of technology transfer offices as well as the readiness of academic staff to work with companies. Conversely, this has been accompanied by an increasing level of institutionalised scientific best practice within companies, such as a willingness to support appropriate publication of research results. Therefore, this potential convergence of perspectives indicates that the dynamics of university-industry research collaboration are continuing to change and will of course be subject to further change in the future. Nevertheless, there can be many challenges with establishing and delivering successful research partnerships. The social underpinnings that support the working relationships between academic staff at universities and industrial staff in companies can be particularly important and consequently can have a significant impact on how research partnerships are structured and delivered.

On a general basis the risks from strategic partnerships between different organisations has been shown to be determined by the level of trust and control associated with the partnership [32]. Risk can be considered as being one of two types, which are relational risk, and performance risk. Relational risks for strategic partnerships would involve the uncertainty over whether or not the partners will cooperate with each other satisfactorily, whereas performance risk would involve other factors that can impact on partnership performance, such as changes in the governmental or regulatory environment, competition from other organisations as well as the necessary competencies of the partners. In the case of relational risk, trust can be a major determinant because a greater level of trust through more open dialogue can help improve cooperation between partners [33]. Conversely, control can be a major determinant of performance risk since effective control mechanisms, such as regular monitoring of performance and project milestones, will help facilitate improved communication and decision-making.

This approach can be further applied to the case of university-industry research partnerships through identifying how strong levels of trust and control are developed to underpin the success of partnering initiatives. The level of trust associated with such partnerships may be built on honesty, regular communication and feedback and also through norms of reciprocity and sharing of information. Similarly, adoption of effective and efficient control processes that build trust and confidence, such as from establishing a governance board to oversee the strategic direction of the partnership, can be undertaken.

In order to help summarise how social capital can be related to research partnerships, Fig. 6 provides a conceptual view based on the framework by Grootaert and van Bastelaer [34]. This framework identifies two dimensions of social capital: spanning the micro to macro environment; and the continuum from cognitive to structural characteristics. The framework has been populated with characteristics for research partnerships according to these dimensions, and use of such a planning tool would help collaborators to frame social and wider issues that can potentially impact on partnership performance. For example and in the case of cognitive features (i.e. those relating to decision-making, problem solving and review activities), the framework identifies key activities to support establishing norms, trust and values, such as through regular and open dialogue as well as from sharing of research results.

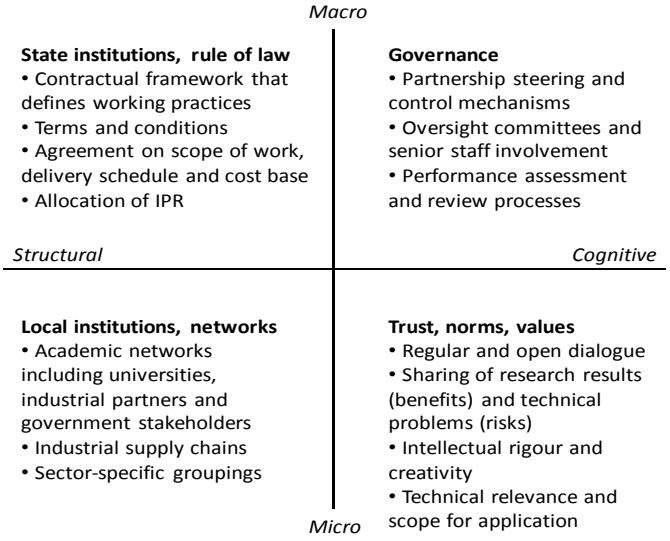


Fig. 6: Conceptual view of social and wider factors for partnerships; adapted from framework by Grootaert and van Bastelaer [34].

Through building on the literature review and resulting consideration of the supporting factors, university-industry research partnerships can be conceptualised within a management framework based on the need for alignment between the university and company in three core areas, namely, technical, commercial and social. This management framework is provided in Fig. 7.

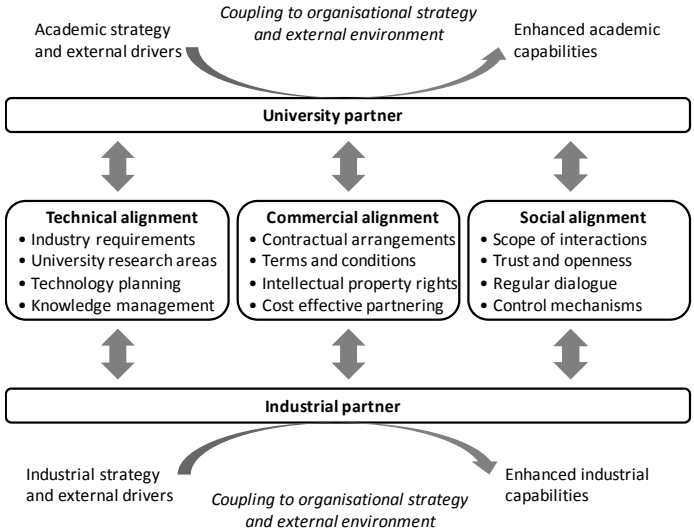


Fig. 7: Management framework for university-industry research partnerships.

## IV. CASE STUDY INVESTIGATIONS

In order to explore the management framework and the supporting alignment mechanism, insights from three case study investigations are provided. The case studies involved reflective analysis by the author on the activities carried out during the development and management of the respective research partnerships in respect to the proposed framework. This approach allows contextual details to be provided on how the management framework can be deployed by practitioners involved with research partnerships. Through consideration of the partnership activities and supporting management techniques adopted, the case study findings are reported according to the three alignment areas as follows (see Tables 1, 2 and 3).

### *A. Investigation of research partnership (1)*

TABLE 1: CASE STUDY FINDINGS ACCORDING TO AREAS OF ALIGNMENT FOR RESEARCH PARTNERSHIP (1).

| |
|---|
| **Partnership background** |
| • Research partnership between a UK industrial company and a single university. The partnership was developed over a two-year timeframe followed by delivery over five years. The partnership had a broad-based remit covering research, education, recruitment and outreach activities.<br>• Over a five-year period (2008 to 2013) approximately £12M of research projects were funded by the company at the university. |
| **Technical alignment** |
| • Industrial requirements for research were initially captured, e.g. need to understand how metallic materials behave under high pressure.<br>• Research audit was carried out at the university to identify key research areas and corresponding academic groups/departments having capabilities relevant to the identified requirements, e.g. plasma physics and high-strain rate physics.<br>• Research proposals were developed in a 'bottom-up' fashion that addressed these requirements whilst being of strong interest to the academic faculty, e.g. shock physics and impact science response of metallic materials.<br>• Joint university-company research workshops were held (e.g. in materials modeling, and computational science), which brought together industry and academic staff for structured two-day meetings that had clear objectives and resulted in technical teams being formed with proposals submitted thereafter.<br>• Overall technical direction of the partnership was provided by a joint university-company board of management. |
| **Commercial alignment** |
| • The partnership was built around a master (framework, or tasking) agreement, which allowed the main contractual terms and conditions to be negotiated from the outset thereby enabling a more efficient contracting approach for individual projects or tasks that can be initiated during the term of the overall master agreement.<br>• The agreement had a guaranteed level of research funding for the university but the company had discretion of when to enable (task) the individual research projects.<br>• Intellectual property rights (IPR) were allocated on a project-by-project basis with an expectation that the university owned foreground IPR (with preferential rights for the company) unless the company made a commercial case otherwise.<br>• Governance arrangements included oversight by a senior level board of management that met three times per year with overall direction provided by the board and annual reports submitted to the board that summarised progress of the partnership.<br>• In addition to reporting of research progress the performance of the partnership was measured according to an agreed set of quantitative and qualitative metrics that provided information on financial leverage and additional benefits according to four categories: Direct investment by university (1); Reduction in contract overheads (2); Research cost avoidance (3); Knowledge sharing and transfer (4). This approach allowed the company to capture and examine the wider benefits arising from its investment in research at the university. |
| **Social alignment** |
| • In regard to development of the partnership and at the exploratory stage, links were formed between the university and the main stakeholders for research in the company (including links at different levels).<br>• A programme manager was appointed at the university to manage the partnership alongside an 'opposite number' at the company to manage the relationship. Also, senior level 'partnership champions' appointed at both the university and company to oversee the partnership from a strategic perspective.<br>• A joint company/university board of management was established, including representatives from the company (chief technical officer, department and technical managers, contracts manager and university liaison manager) and the university (senior faculty/dean level, commercial manager and programme manager).<br>• There was joint university-industry supervision of research projects with the active involvement of scientific staff from the company.<br>• The partnership included appointment of visiting staff from the company as visiting professors who give lectures and seminars at the university and supervised PhD students and also visiting researchers/fellows who participated in experimental campaigns at the university. A number of junior industrial staff from the company were also seconded to the university to undertake masters and PhD level degree programmes. |

### *B. Investigation of research partnership (2)*

TABLE 2: CASE STUDY FINDINGS ACCORDING TO AREAS OF ALIGNMENT FOR RESEARCH PARTNERSHIP (2).

| |
|---|
| **Partnership background** |
| • Research partnership between a UK industrial company and a single university. The partnership was developed over a one-year timeframe followed by delivery over three years and an extension of the partnership for an additional three years. The partnership was based on delivery of a set of research and technology objectives that included fundamental research and technology development.<br>• Over a six-year period (2006 to 2012) approximately £2M of research projects were funded by the company at the university. |
| **Technical alignment** |
| • Industrial requirements for research were captured, e.g. development of multi-functional materials that had both structural and electronic properties.<br>• Research audit was carried out at the university to identify key research areas and corresponding academic groups/departments having capabilities relevant to the identified requirements, e.g. composite materials and material mechanics groups.<br>• Research proposals were developed in a 'bottom-up' fashion that addressed the requirements whilst being of strong interest to the academic faculty, e.g. |

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|---|
| processing, fabrication, characterisation and fracture mechanics for metal matrix composites.<br>• Partnership was developed around four technology themes and technical planning included use of technology roadmapping and assessment of R&D areas in relation to TRL (technology readiness level) frameworks. This allowed a phased development initiative to be planned for each theme area, where technologies with a higher TRL could be transitioned to pre-manufacture fabrication and testing in the shorter timeframe, whereas technologies with a lower TRL could receive targeted funding to reduce technical risks and thereby transition to a higher TRL when appropriate.<br>• The partnership included an innovation scheme where short technology projects could be funded by the company, which involved feasibility studies on the development of a particular materials research area to meet an industrial requirement.<br>• Overall technical direction of the partnership was provided by a joint university-company executive board. |
| **Commercial alignment** |
| • The partnership was built around a framework agreement, where the main terms and conditions were agreed at the outset and then individual projects could be initiated according to industrial requirements.<br>• The agreement included an initial phase of projects that were three years in duration although funding was released on an annual basis according to the three year funding profile. Upon completion of the three-year projects, a further set of follow-on projects were initiated.<br>• Intellectual property rights (IPR) were allocated to the university for all projects but with non-exclusive royalty free (NERF) rights for the company along with access to background IP on commercial terms.<br>• Governance arrangements included oversight by an executive board in addition to an advisory board that had a particular focus on directing the industrial development of technologies. This advisory board included a number of companies that were involved in the technology supply chain of the primary industrial partner. |
| **Social alignment** |
| • During development of the partnership, a steering committee was formed that transitioned into the executive board once the framework agreement was signed. A programme manager and senior champion were appointed at both the university and company to manage and oversee the relationship respectively.<br>• The executive board had representatives from both the company and university. Representatives had functional responsibilities across technical/academic, commercial, business and human resources areas thereby allowing the board to draw on a broad base of intellectual input and support from each organisation.<br>• There was joint university-industry supervision of research projects with the active involvement of technical staff from the company. |

*C. Investigation of research partnership (3)*

TABLE 3: CASE STUDY FINDINGS ACCORDING TO AREAS OF ALIGNMENT FOR RESEARCH PARTNERSHIP (3).

| |
|---|
| **Partnership background** |
| • Research partnership involving a consortium of six UK industrial companies (with one company acting as the prime contractor) along with five universities. The partnership was developed over an 18-month timeframe followed by delivery over a further four years. The partnership was based on the need to meet a series of research objectives across a defined portfolio of technology areas.<br>• Over a four-year period (2006 to 2010) approximately £150k of research projects were funded by the company at the university. |
| **Technical alignment** |
| • Industrial requirements for research were captured, e.g. development of an integrated modelling system to support the design and manufacture of robust packaging units for high-performance applications.<br>• Research audit was carried out at the university to identify key research areas and corresponding academic groups/departments having capabilities relevant to the identified requirements, e.g. multi-scale modelling, mechanics and dynamics groups.<br>• Research proposals were coordinated through a 'top-down' approach that sought to generate proposals that addressed the defined industrial requirements, e.g. Eulerian modelling and computational fluid dynamics (CFD) simulation research on a series of different design configurations.<br>• Partnership was developed around five research themes and technical planning included use of technology roadmapping frameworks. Technology roadmapping was used to establish a clear pathway from the early-stage long-term research areas to more applied studies and eventually to technology development, manufacture, testing and in-service commissioning. This detailed planning work helped the company to understand the potential impact for investment in the research and also to underpin the case for investment in external research at the consortium partners.<br>• Technical direction of the partnership was provided by a joint university-industry management committee that included representatives from each of the consortium partners. |
| **Commercial alignment** |
| • The partnership was initially established through a memorandum of understanding (MOU), which was signed by each of the consortium members. The consortium was led by a prime contractor industrial partner, which managed the commercial arrangements, including drafting of the MOU and an accompanying non-disclosure agreement (NDA).<br>• Once the MOU had been signed by all the consortium parties, there was a long and detailed negotiation of a tasking contract. The tasking contract had an initial four-year term although it could be renewed for an additional four years. At the outset there were no projects set up as they had to be commissioned gradually according to the industrial requirements. There was no minimum or guaranteed level of funding for any of the consortium partners.<br>• The tasking contract did allow the main terms and conditions to be agreed from the outset although IPR had to be negotiated on a project-by-project basis and there was no initial agreement on how foreground or background IPR would be allocated.<br>• Governance arrangements included oversight by a partnership board that was supported by the aforementioned management committee in regard to technical direction. The partnership board included members only from the industrial companies and the majority of the members were from the prime contractor. |
| **Social alignment** |
| • Programme managers were appointed at both the university and the company although there was no senior level champion for the initiative at either the university or the company.<br>• Since research proposals were coordinated through a top-down approach, academic staff from the university were not extensively involved in the partnership and there was a subsequent lack of engagement with the initiative.<br>• The partnership board was dominated by industrial representatives with no academic involvement. Academic institutions were part of the supporting management committee although this grouping had limited terms of reference that were focused on recommending technical direction of the partnership.<br>• There was no industrial joint supervision of the small number of academic research projects that were initiated. |

The case study investigations identified the various activities that were carried out across the three university-industry research partnerships. These partnerships all involved scientific research in academic disciplines related to engineering and physical sciences at the university. The partnerships involved UK companies engaged in the development of technologies for various industrial applications. Research partnerships (1) and (2) resulted in a significant number of research projects being initiated at the university, whereas partnership (3) resulted only in a minor level of research activity at the university.

Research partnership (1) was a strategic initiative for both the university and the company. The company committed significant resources to the partnership, including financial support as well as support through the involvement of technical, commercial and senior management staff. Once the partnership had been established, the company was able to develop close links with the university through a number of complementary mechanisms, including joint working, sharing of information (such as industrial requirements and other information relating to technical and industrial developments) as well as through regular and open dialogue. These activities were supported through a clearly defined approach to governance, including strategic oversight of the partnership accompanied by periodic review of the performance of the partnership across an integrated set of KPIs (key performance indicators). The partnership was closely aligned with the technical capabilities of both the company and the university and this ensured the support of major stakeholders from each organisation. Commercial arrangements were also clearly defined and managed in a professional manner to ensure reciprocal benefits for both partners. Participation in the partnership resulted in significant benefits for both the company and the university. The company was able to benefit from an early insight into emerging research areas that could be focused towards development of technologies to support the company's strategic objectives. The company also benefited from the transfer of technical knowledge, including explicit knowledge (e.g. data and information on the physical properties of various metallic materials) as well as tacit knowledge (e.g. the skills and expertise required to undertake advanced spectroscopic analysis of different classes of materials). The university benefited from the partnership through funding secured for researchers, PhD students and for the procurement of new equipment. There were also benefits from the close working with an industrial company that allowed the research to be developed further towards eventual commercial application.

Research partnership (2) was a targeted research partnership that delivered a number of high-impact research and technology projects in a defined scientific area. The partnership secured the support of senior academic staff as well as senior stakeholders at the company. There was close technical alignment between the company and university, and technology roadmapping and TRL frameworks were used extensively to support the research planning activities. The partnership included a focused approach to the commercialisation of technology through, for example, the funding of short feasibility studies that enabled a rapid assessment of emerging technologies of interest. Inclusion of other companies that were part of the industrial partner's supply chain also helped to provide a strong focus on the commercial application of promising research areas. The partnership was supported by a robust but flexible approach to contracting that allowed the main terms and conditions to be agreed from the outset. Both the university and company exhibited degrees of flexibility in regard to the negotiation of IPR arrangements that were beneficial to both parties. Also, both the company and university benefited from participation in the partnership. The company was able to assess the opportunities for incorporating arising technologies into its supply chain while the university secured industrial funding and access to an industrial channel for promising research to be routed through.

Research partnership (3) benefited from a coordinated approach to the capture of industrial requirements although research proposals were directed through a 'top-down' approach by senior management. This differed from the other two partnerships that involved proposals being generated through a 'bottom-up' fashion, i.e. academic staff were free to submit proposals according to their research interests as long as they were within the remit of the overall set of industrial requirements. Consequently, partnership (3) did not secure extensive involvement of academic staff at the university and this may be because their academic creativity was being stifled by the company's approach to proposal generation and review. Although partnership (3) was supported by an MOU and NDA, the tasking contract that was negotiated for use by the consortium members required extensive multi-party review and negotiation. This extended negotiation period may have damaged the perception of the partnership within the consortium member organisations and therefore resulted in difficulties in sharing information relevant to the partnership, which in turn diminished the level of trust (and social capital) associated with the partnership. The partnership's governance structure and processes were heavily weighted in support of industrial interests and this further exacerbated the lack of academic engagement in the initiative. The outcome of this lack of engagement was that the industrial company was not able to benefit from promising research at the university and therefore the company's competitive position was not enhanced through participation in the partnership. The university did not benefit significantly either as there were only a small number of short research projects initiated, which did not allow recruitment of new postdoctoral researchers or new graduate students and consequently the university's academic capabilities were not enhanced through participation in the partnership.

In terms of assessing the partnerships in regard to the management framework provided in Fig. 7, it is useful to

consider the relative levels of alignment for the three partnerships and this is captured in the diagram in Fig. 8. This schematic view identifies that research partnership (1) has a high degree of alignment in all three areas, which is consistent with the performance of this partnership which was very high in terms of enhanced industrial and academic capabilities for the company and university respectively. Partnership (2) had a high level of technical alignment but commercial and social alignment were both at medium levels. Whilst this partnership was successful, it did not have the same level of commercial and social integration as partnership (1). Partnership (3) had a medium level of technical alignment but commercial and social alignment were both at low levels. This partnership benefited from an initial significant level of technical integration but ultimately suffered from a poor level of commercial and social integration, which resulted in the partnership failing to provide enhanced industrial and academic capabilities for the company and university respectively.

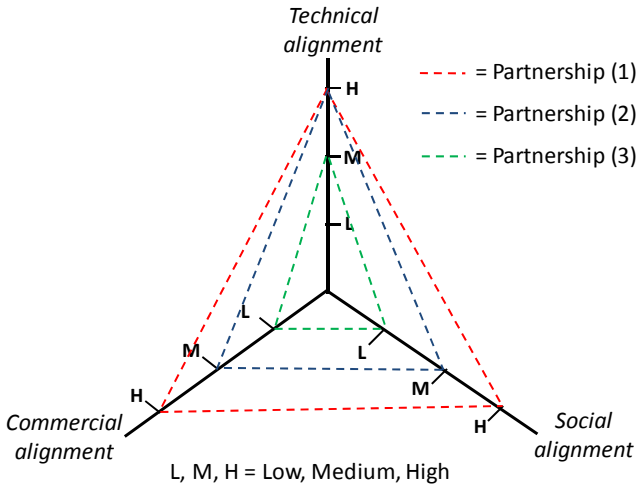


Fig. 8: Schematic view of relative levels of alignment for the three partnerships investigated.

## V. CONCLUSIONS AND FUTURE WORK

This paper has provided a discussion for the underlying basis and supporting factors for research partnerships between industrial companies and universities. The benefits for establishing such partnerships have been identified along with the provision of data on the extent of industry financed R&D and contract research at US and UK universities respectively. The literature review has allowed three main categories of factors to be identified that have the potential to impact on the performance of university-industry research partnerships, namely technical, commercial and social. Frameworks have been provided for each of these areas to help practitioners work through the practical steps and activities that can be pursued to help facilitate partnerships. Moreover, a conceptual model has been developed that is based on the need for alignment between the company and university across these three supporting areas and it is proposed that when such alignment is optimised the effectiveness and efficiency of the partnership process will be improved thereby enhancing the industrial and academic capabilities at companies and universities respectively.

The proposed management framework has been explored through a series of three case study investigations, which have allowed contextual details to be provided on the types of management activities that can be undertaken and the subsequent impact they can have on the performance of the partnership. The framework provides scope and flexibility for different approaches to be used within the three areas of alignment although it is recognised that the specific activities undertaken to develop and manage a given partnership will be contingent on the circumstances and background of the particular partnership, which can be viewed in the context of contingency management theory [35].

Through analysis of the case study findings, it can be discerned that many of the factors that have the capacity to impact partnership performance are systemic in nature and therefore taking a holistic view on partnerships is prudent. For example, ensuring partnerships are subject to appropriate levels of governance through engaging senior stakeholders from the company and university can be viewed in commercial terms (i.e. as stipulated in a contractual agreement) and also in social terms (i.e. involving the necessary staff and subsequently gaining their support and enthusiasm for the partnership). In this example, an inability engage senior staff in the governance process would therefore weaken both commercial and social alignment and consequently negatively impact on the performance of the partnership. This systemic nature of partnerships is indicative of the collaboration process, which can be non-linear and complex through the involvement of many factors (and actors and/or stakeholders). Consequently any proposed management framework or process methodology must only be considered as broad-based guidance to help reduce risks and improve the probability of the partnership delivering sustained benefits for the parties involved.

In regard to commercial arrangements, there is the need for a clear and open approach to the allocation and management of IPR [36]. On this matter, both universities and companies will naturally seek to secure a favourable IP positions and there is not necessarily a 'one-size-fits-all' type of solution that is applicable here. Instead it is suggested that at an early juncture point in the development of the partnership both parties identify the primary requirements for the partnership and that a robust commercial model is established that allows these requirements to be optimally delivered. A joint university-industry project team, including commercial and technical/academic staff, should then work through the appropriate IP options, and the team will need to be empowered to develop a contractual position on IP that provides benefits (and corresponding sharing of risk) for both collaborating partners. The commercial model can also

benefit from highlighting how the performance of the partnership will be measured. This can include the use of performance measurement tools, such as the balanced scorecard [37] and also extend to capturing research cost avoidance [38], i.e. the costs the company would incur if it decided to carry out the research internally and not at the university.

The involvement of academic staff at the university and technical staff at the company is of course pivotal to the success of any research partnership but the appointment of a dedicated project manager in both organisations can help ensure the partnership is managed efficiently and the required tasks are completed in a timely fashion. For strategic level partnerships it is also recommended that a senior level 'partnership champion' is appointed at both organisations and at companies this could be, for example, the CTO (Chief Technology Officer) or equivalent and at the university it could be a senior faculty member (i.e. Dean, Department Chair or equivalent). Although this would not need to be done for a more tactical level partnership, which further highlights the contingency aspects of managing research partnerships.

In addition to considering the organisational structures and processes to support collaborative partnerships it is useful to highlight the supporting behaviours and boundary spanning [39] can be an important skill for staff involved with research partnerships. This can be viewed in terms of the need to manage across organisational boundaries, e.g. through coordinating the technical and contractual interactions between both partners as well ensuring that senior stakeholders from both collaborating organisations are kept up-to-date on key developments of the partnership. Further attributes associated with boundary spanning include the ability to bring together different academic disciplines in order to provide the industrial partner with a multidisciplinary research capability [40]. From the university perspective, academic staff will benefit from having boundary spanning skills but this requirement can additionally be met by industry liaison offices that provide centralised support to faculty members [41]. Similarly and from the industrial perspective, academic liaison managers can provide coordination across the company for interactions with universities.

The management of knowledge flows between collaborating partners is important and therefore ensuring nominated staff act as contact points for the partnership can help in this regard. From the industrial viewpoint, the ability to efficiently acquire and integrate the results and knowledge from research collaborations with universities can be an important consideration and this can be viewed using the concept of absorptive capacity [42]. Companies need to consider whether they have the necessary resources as well as staff with the skills and motivation to adequately utilise arising knowledge created from the academic research. Questions that could arise include whether there are suitable opportunities to advance the research findings in an industrial environment, for example, as part of a technology demonstration and testing programme? Furthermore, are promising technologies sufficiently developed (i.e. having a suitably mature TRL) to be integrated into the company's supply chain so as to enhance competitiveness? These are just some of the questions that can be addressed through a strategic partnership, which can help provide the technical, commercial and social environment to frame such matters.

Deploying the alignment-based management framework for developing and managing university-industry research partnerships should be part of a planned approach and various mechanisms (e.g. requirements capture, technology roadmapping, TRL frameworks, commercial models, stakeholder mapping, and others) have been described in this paper that can be carried out by practitioners during this planning process. Once a particular collaboration has been initiated there is the need to implement such planning thereby generating the collaboration outputs and benefits for the parties concerned. Again the paper has provided practical insights to help in this regard, such as the benefits in research proposals being generated by academics in a bottom-up fashion whilst remaining within the overall industrial remit of the collaboration.

In regard to future work it is suggested that the research findings are extended through examining different types of research partnerships with differing scope (i.e. in terms of research, teaching or consultancy activities undertaken) or size (i.e. in terms of financial value or number of collaborators). It is further proposed that a classification of the types of partnerships between universities and companies is developed as well as the development of quantitative metrics for measuring the outcomes from university-industry research partnerships. Finally, the systemic or non-linear nature of the collaborative process would benefit from further enquiry and the use of systems diagramming and appropriate modelling techniques is advised on this matter.

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