**Knowledge Management Strategy for**

**university-Industry research Collaboration**

##

## Simon P Philbin PhD MBA, Imperial College London, United Kingdom

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

# Abstract

Companies across different industrial sectors collaborate with universities in order to secure a knowledge advantage and benefit from technology transfer opportunities. This subject has been studied widely yet there is very little coverage of how to develop knowledge management strategies in this context. Following a literature review a knowledge management framework will be developed that includes the generation, capture, communication and application of knowledge. The framework will be explored through a case study investigation of a major collaborative programme between a UK university and an industrial company. The case study involved reflective analysis of how the knowledge management strategy was formulated and delivered to support the collaboration and also how performance was measured holistically across the collaborative programme. Findings point to the non-linear nature of collaboration and the merit in viewing knowledge flows from an integrated systems perspective.

# Introduction

Companies from a number of different industrial sectors collaborate with universities in order to gain a knowledge advantage (Bayh and Allen, 2012). This has been described as an important component in the development of the knowledge economy through supporting enterprise and growth, thereby enabling substantial benefits for industry and the academic sector (Agrawal, 2001). Indeed university-industry research collaboration has been associated with a number of industrial motivations, such as the need for companies to gain access to academic creativity and specialist knowledge (Philbin, 2008). There may be interest in specific technologies to improve the performance of particular products or services, or there could be interest in gaining access to the university’s wider networks (Santoro and Bierly, 2006). This partnering and collaborative activity can be viewed in the context of the open innovation agenda (Chesbrough, 2006), where historically companies carried out research in-house but there has been a movement towards sourcing research and innovation practice from external providers (Rafols, 2007). Such collaboration is driven by greater competition and the pace of development in high-tech sectors, and also by the realisation that companies can enhance their competitive position through leveraging available technologies and not just those developed internally that can be increasingly costly to deliver.

 Considering different industrial sectors and for example within the pharmaceutical industry, pharma companies partner with universities to gain access to clinical data along with medical insight from university hospitals so as to incorporate this knowledge into the drug development process. In the electronics hardware sector, for example, there are industrial collaborations with academic departments working on the development of new microfabrication processes for MEMS (Micro-Electro-Mechanical Systems). Furthermore, in the aerospace sector, airframe manufacturers collaborate with universities on computational modelling of composite structures to determine damage and failure mechanisms. These examples highlight how companies are working with universities across different sectors in order to gain specific knowledge inputs and in some cases valuable intellectual property (i.e. through patents, or license agreements), which can then enhance the company’s knowledge base and ultimately contribute to new product development (NPD).

 Studies have highlighted there is a need to examine how to optimally structure and manage university-industry collaborations (Kirkland, 2005) so that knowledge benefits can be realised. Indeed McAdam et al. (2006) have indicated there has been a lack of process-oriented research into how the performance of research collaborations can be improved. Ultimately university-industry research collaborations can be related to the generation and eventual application of knowledge outputs and it is therefore a logical extension that the management of these collaborations will benefit from adoption of an underpinning strategy for knowledge management. Therefore, development of a supporting strategy that provides guidance on the required management structures and processes should contribute to enhancing the performance of university-research collaborations.

 Consequently, the objective of this paper is to report on a research study into the formulation of knowledge management strategy to support university-industry collaboration. Following a literature review a knowledge management framework will be introduced, which will be explored through a case study investigation involving a strategic collaborative programme between Imperial College London (the university) and a UK industrial company.

**Knowledge Management**

The field of knowledge management (Nonaka, 1991) has been developing rapidly over the last couple of decades (Zheng, 2010). However, early explorations of the subject were highly conceptual and there was an apparent lack of detailed research on how knowledge management strategies could be implemented in real world situations and thereby become viable for practicing managers. Knowledge management has been viewed in terms of the performance of a firm being related to its ability to mobilise knowledge resources and convert them into “value-creating activities” (von Krogh, 1998), with value creation being linked to sharing of generated knowledge, experience and practice, and the subsequent deployment and application of knowledge contributing to new product or service offerings.

 The process through which companies establish and benefit from new business channels, such as partnering with universities, can therefore be seen as a potential enabler for the provision of additional value-creating activities ultimately leading to improved products. Knowledge has also been incorporated through extension of the resource-based view of strategy (Spender, 1996), where knowledge that is difficult to imitate or acquire can be a major determinant of an organisation’s competitive advantage (Philbin, 2012). Due to the prevalence of technology in modern products, services and manufacturing processes, coupled with knowledge being the major determinant of technology performance, the ability to acquire and deploy knowledge can be regarded as a principal source of value and consequently one of an organisation’s most valuable assets (along with the employees).

 Knowledge itself has been described as being either explicit or tacit (Polanyi, 1958). Explicit knowledge can be readily codified [e.g. experimental research data in an SQL (structured query language) relational database], whereas tacit knowledge can be difficult to transfer and codify (e.g. a practical technique for operating a technical instrument). Seminal work by [Nonaka](http://www.google.co.uk/search?tbo=p&tbm=bks&q=inauthor:%22Ikujir%C5%8D+Nonaka%22) and [Takeuchi](http://www.google.co.uk/search?tbo=p&tbm=bks&q=inauthor:%22Hirotaka+Takeuchi%22) (1995) highlighted how Japanese manufacturers in the automotive and electronics industrial sectors have benefited from being able to capture tacit knowledge to improve the manufacturing process. These influential authors also describe the role of middle management (through the so called ‘middle-up-down’ approach) to bridge the gap between the strategic goals of senior management and the chaotic realities on the ground. Utilising a knowledge advantage is of course important for organisations that operate in scientific and technology centric sectors, such as oil and gas, pharmaceutical, defence and aerospace, and general engineering. Moreover, knowledge management processes have been viewed as the mechanism to manage intellectual capital through a systematic approach that will necessarily involve an emphasis on sourcing and creating knowledge as well as development, organisation, and the leveraging of the resulting knowledge (Wiig, 1997). Correspondingly knowledge management is likely to become an increasingly common feature within technology focused sectors where a company’s competitiveness can be directly related to its ability to acquire and deploy new knowledge (Abdullah et al., 2005).

 Organisational knowledge management has been articulated as comprising a number of contributing elements that need to be present in order for knowledge flows to be optimised and for organisational learning to take place (Alavi and Leidner, 2001). On a systemic basis and at the initial stage there is knowledge construction and organisation, followed by knowledge storage, transfer, and finally application (Holzner and Marx, 1979; Pentland, 1995). This viewpoint and categorisation of knowledge process steps can be illustrated by the following example. Development of a new materials analysis technique by a university researcher would represent ‘knowledge construction’, whereas gaining an understanding of which materials systems and the corresponding experimental conditions needed to be employed would be ‘knowledge organisation’. Collectively these two knowledge processes can be associated with knowledge creation, or generation. Incorporation of the parameters for conducting the analysis technique in an experimental database would be ‘knowledge storage’, and the subsequent publication of these results in a technical journey would represent ‘knowledge transfer’. Finally use of the analysis technique by a researcher from a different organisation, such as a university or company, would correspond to ‘knowledge application’.

 In the context of research collaborations, explicit knowledge can be data and information that has been codified in a database, such as the vibrational frequencies for electronic materials and then published in a materials journal. Conversely, tacit knowledge could be an understanding of how to carry out a particular experimental technique, such as a methodology for quantitatively determining the molecular composition of chemical mixtures using nuclear magnetic resonance (NMR) spectroscopy. Consequently, the ability to capture and record knowledge (or to codify) and subsequently transfer to an interested party would appear to be a central feature of knowledge management. Indeed Schultz and Jobe (2001) have described how focused knowledge management strategies regulate the degree to which knowledge is captured and codified and how this can lead to increased organisational performance. This work also highlights how different types of knowledge need to be codified accordingly, depending on the nature of the knowledge. In regard to university-industry research collaboration, for example, raw data on the mechanical testing of new structures can be codified in a database. Conversely it may be more practical and convenient to codify user insights into the development of a new networking protocol for cloud computing, through provision of a technical seminar or course that highlights the different techniques and parameters required to support the protocol.

 Industry supported research collaborations will be required to generate knowledge outputs in the form of research results that can be used to inform industrial requirements for new technologies. Once such knowledge has been produced, there will be the need to capture the knowledge and for it to be available to interested parties through accessing a suitable knowledge repository or data storage system. Consideration of the appropriate channels for communication by the university to the company (e.g. through a research report, or as part of a training course as described above) will help in this regard. Indeed work by Zack (1999) highlighted how integration of formal training with interactive forums can enable tacit knowledge to be readily captured and applied, and consequently knowledge creation is combined with knowledge application in an iterative manner.

 Developing a model for knowledge management needs to take account of a number of different factors (Moffett et al., 2002), including the macro-environment and organisational climate as well as technological, informational, cultural and people factors **(**Skyrme, 1999)**.** This wider interpretation of knowledge management seeks to explain how successful adoption of knowledge management systems can be dependent on a range of organisational attributes. There needs to be a supporting culture to accept any changes in working practice, and there will need to be people willing to effectively champion the new system. The requisite data, information and knowledge will need to be readily accessible in order to facilitate the eventual application in the context specific environment. Consequently, this access and application will need to be supported through the use of available information technology (IT) to enable the knowledge management system. Indeed it has been reported that this availability of IT systems has more generally been responsible for driving the development of knowledge management and across different organisational settings (Borghoff and Pareschi, 1998).

 In the energy sector, oil companies use enterprise IT systems to manage technical information and quality standards for various petrochemical materials and industrial processes (Edwards, 2008). Within the healthcare sector, there is significant scope to use knowledge management systems to integrate large amounts of clinical data (Dwivedi, 2008) and especially in emerging areas such as bioinformatics for epidemiological or public health studies. Knowledge management systems have also been investigated within the higher education field as a tool to support the management of teaching activities (Arntzen et al., 2009). This latter work identified how the system created an environment for cross-organisational learning and supporting knowledge sharing processes as part of communication and cooperation between staff and students.

**Strategy Development**

Through building on the literature review it can be observed that in the context of university-industry research collaboration there are four main elements to a knowledge management strategy and these are knowledge generation, capture, communication, and application. Alavi and Leidner (1999) have described three perspectives on knowledge management, which are information-based, technology-based, and culture-based. Consequently, in order to examine the features and artefacts of a knowledge management strategy to support university-industry collaboration, these perspectives have been applied to the four elements (see Exhibit 1 overleaf).

 Through analysis of the main elements it is possible to conceptualise knowledge management strategy as an integrative model where the overall performance of the university-industry collaboration will be dependent on the contributions from the individual parts of the system. Exhibit 2 provides this conceptual model.

**Exhibit 2**. Knowledge management strategy (integrative model) for university-industry research collaboration.



 It is suggested that collaboration performance will be influenced by a broad range of determinants across technology, management and cultural considerations. It is therefore proposed that instead of universities and companies managing knowledge flows for research collaborations in an ad hoc manner, a coordinated approach is used to underpin and thereby optimise the collaboration process.

**Exhibit 1**. Analysis of main elements of a knowledge management strategy for university-industry research collaboration.



**Case Study Investigation**

The case study investigation involved application of the knowledge management strategy to a major collaborative programme between a UK university and an industrial company, which included a range of research, education and experimental facilities development projects. The collaboration underpinned the establishment of the Institute of Shock Physics, a multidisciplinary institute at Imperial College London (the university). The research study involved reflective analysis by the author on the activities carried out according to the four elements of the knowledge management strategy. In order to furnish background to the study, Exhibit 3 provides a schematic view of the Institute’s five-year programme schedule and Exhibit 4 provides the outline technical strategy.

**Exhibit 3**. Schematic view of Institute’s five-year programme schedule.



**Exhibit 4**. Institute outline technical strategy.



 The following exposition provides a description of some of the main activities undertaken within the four elements of the knowledge management strategy for the Institute’s collaborative programme with industry. This contextual analysis concentrates on the knowledge-based issues and how they related to the initiation and delivery of the overall collaboration.

**(i). Knowledge generation**. The university initially became aware of the opportunity to establish a major new university-industry partnership with a company and consequently the industrial requirements for shock physics were captured from the company. This involved analysis of explicit information from documents, reports and technical publications on the behaviour of materials under high pressure and related areas of shock physics. Requirements were also captured from meetings with the company and therefore tacit information on the industrial priorities for research and education could also be ascertained. These requirements were then organised into a series of research and education areas and recorded in a spreadsheet for later analysis and review as part of development of the collaborative programme proposal.

 Following capture of the industrial requirements the university was able to undertake a technical audit of research capabilities to identify how the requirements could be met. A technical working group was convened that included senior academic faculty along with a programme manager. This working group coordinated with other academic teams across the university in order to produce a number of research proposals that addressed a major part of the industrial requirements. These proposals were prepared in order to address the industrial requirements that had been captured but they also brought together multidisciplinary research areas across the university. Requirements that were not met were allocated to partner universities and consequently an open and inclusive approach to collaboration was adopted.

 Once the proposals had been funded by the company the research projects were delivered as part of an overall university-industry collaborative programme. Projects were carried out across a number of academic departments at the university and also there were projects at the partner universities. This approach to partnering with other universities ensured that the programme was both collaborative and multidisciplinary. There was research carried out in the Physics Department, Aeronautics Department, and Earth Sciences Department. The research included both experimental studies (e.g. using high pressures gas guns, diamond anvil cells, and pulsed power driven shocks) as well as computational studies, such as Eulerian modelling of shock waves and impact events. In this regard, care was taken to ensure an appropriate balance of experimental and computational research whilst remaining aligned with the industrial requirements. Initially computational studies were designed to leverage previous research from other application areas but as the collaboration developed a greater emphasis was placed on designing computational projects that could generate data to allow new experimental regimes to be investigated.

**(ii). Knowledge capture**. Data and information produced by the research projects was captured through a number of mechanisms. Data was obtained from the various experimental campaigns that were undertaken, e.g. data on the response of different metallic alloys to pressures in the gigapascal (GPa) range. This data was initially captured in laboratory information management systems (LIMS). Subsequent analysis of the data allowed research results to be communicated to the company at research seminars and colloquia and this will be described in more detail in the next sub-section. Experimental results were codified in research papers (journal and conference papers), which represents another knowledge communication channel.

 A major feature of the knowledge capture process was the development and implementation of the balanced scorecard tool (Kaplan and Norton, 2003) to both collect information on the research and education activities carried out by the Institute and also measure performance of the collaborative programme (Philbin, 2011). The scorecard approach was used as a holistic framework that could be adapted to capture the full range of knowledge-based activities being undertaken by the Institute in addition to other financial performance data. Exhibit 5 provides a summary of the scorecard’s reports.

**Exhibit 5:** Summary of balanced scorecard report measurements.



 The scorecard was developed in MS AccessTM as a programme level database that could be accessed by members of the management team. Initially downloads were produced on a quarterly basis and the subsequent MS ExcelTM spreadsheets were submitted to the company for review at meetings of the quarterly operations management board. Both the company and the university were able to use the scorecard reports to track progress of the collaborative programme but crucially in terms of knowledge capture, the scorecard had details of all the publications, research projects, and education activities being undertaken. Consequently, there was a central and readily accessible resource available for staff to use and to support the knowledge management strategy for the overall collaboration. The scorecard reports helped generate a cumulative profile of the knowledge-based outputs of the collaborative programme and the use of standard software ensured the database could be easily accessed.

**(iii). Knowledge communication**. Knowledge outputs from the collaboration were communicated via a number of complementary channels. On a general and wider level, codified data and information was communicated as part of journal papers, lectures and conference papers given at various technical conferences. This would of course represent the traditional channel for knowledge to be communicated.

 In terms of the collaboration itself, the research findings were initially communicated to the company through technical seminars, workshops and focused meetings, where results could be reported and discussed. These meetings were held periodically and included participants from the various university institutions participating in the overall collaborative programme. Research findings were also reported at an annual technical conference, where progress across the research projects could be reported alongside research from other universities and companies involved in shock physics. This conference helped to benchmark the quality of the research and demonstrate its relevance in the context of research activities at peer institutions. In addition to the conference, there was also a series of training courses held, which provided tuition in a given area that was augmented by research results. These technical courses proved to be particularly popular as both explicit and tacit knowledge, such as materials response data as well as an understanding of how to optimally carry out experiments to obtain such data, could be communicated to interested parties including the collaborating company.

 Another major feature of knowledge communication involved close working with the industrial staff through appointment of technical and scientific staff as visiting researchers or visiting academic staff at the university. In some cases visiting staff were also registered to undertake a postgraduate degree at the university, including both PhD and Masters degrees. This co-location of university and industrial staff was manifested through a number of different approaches.

In the case of a major experimental facilities development project, a joint university-industry working group was convened and the grouping was involved in the design and establishment of a complex high-pressure gas gun facility over a three-year period. Joint working ensured issues could be resolved promptly without the need for extended delays associated with decisions that needed to be taken by both the university and the company on the design specifications of the experimental facility. Moreover, specialist scientific input could be accommodated rapidly in the facilities development project, which had to take account of technical direction from both the company and the university.

 Technical staff from the company were also involved in the joint supervision of PhD projects and this level of technical coordination again ensured key research findings could be easily communicated to the company. The joint supervision of research projects ensures that arising tacit information is readily transmitted to the company and not just explicit information that has been captured in research reports by the student.

**(iv). Knowledge application**. In terms of the knowledge management strategy for university-industry research collaboration the process is completed through application of the derived knowledge within the company although of course the knowledge generated will also continue to be applied on current and new research projects at the university. In the case study, research findings on the behaviour of materials at high pressures were communicated to the company and the company was then able to use this data and information to develop and validate new computational models for understanding the shock response of materials. On this matter Eulerian hydrodynamical simulations were carried out by the university in order to improve the fundamental understanding of how shock waves are propagated through a given material. This knowledge can then be used to determine the constitutive equation that relates the response of a given material (such as a metallic material) to an external force (such as a pressure wave).

 The research findings from projects carried out at the university were also used by the company to help design new sets of experiments that could be conducted at the company’s experimental facilities. Information on the operational parameters for such experiments was initially established at the university and then adapted and applied further at the company facilities. This iterative approach allowed the university to conduct a larger range of initial experiments to effectively narrow down the range of options, whereupon a defined experimental system could be adopted for the industrial application area.

 In a situation where specific intellectual property (IP) is generated, e.g. knowledge of a new materials analysis technique, transfer of such knowledge will be governed by the technology transfer terms of the contractual agreement that underpins the collaborative programme. These terms include provisions for the allocation of background and foreground intellectual property rights (IPR) and associated licensing arrangements. The arrangements were stipulated in the framework agreement that supports the collaborative programme. Negotiation of IPR for university-industry collaborations can often present particular challenges for the parties involved (Burnside and Witkin, 2008) and it is recommended that the university and company adopt a flexible approach and that there is clarity on the commercial objectives from the outset so as to avoid complications downstream. In the case study the general terms and conditions were agreed in the framework agreement but the allocation of foreground IP was agreed on a case-by-case basis when each new research project was initiated. This approach allowed the company to retain the decision over the allocation of IPR although in practice both parties were able to readily agree on a favourable outcome for both the university and company.

**Discussion of Case Study Findings**

The case study has highlighted the integrative nature of the knowledge management strategy and how each of the four elements within the model (generation, capture, communication and application) contributes to the overall performance of the university-industry research collaboration. Although knowledge management can in some respects be viewed as an iterative (and cyclic) process, with knowledge generation taking place initially and ultimately leading to knowledge application, it can also be viewed as a non-linear process.

 In order to illustrate this point, the case of a particular shock physics experiment carried out on the university’s large-bore gas gun can be considered. In this example the experiment was undertaken by a PhD student who was on part-time secondment from the company. When the experiment was carried out, the research data was collected through the data recorder and a set of pressure readings for shock wave propagation were gathered using a laser velocity measurement system. In this scenario the PhD student acquired new knowledge on how to set up the experiment and collected data using the diagnostic equipment through the supervision given by the academic faculty. Consequently, since the student was on part-time secondment from the company, the student was therefore able to immediately apply the acquired knowledge within the company. This tacit knowledge of how to configure the experiment, and how the results can be interpreted to generate the constitutive equation for the metallic material under investigation, could be passed on to colleagues within the company who were able to integrate into other planned experiments on different materials. Therefore, knowledge application occurred back-to-back with knowledge generation. Moreover, research findings were discussed at meetings and recorded in technical databases.

 This was followed by further interpretation of the findings and analysis with experimental results along with the research findings from other students and postdoctoral researchers. After a period of time, these results were then systematically ordered, analysed and interpreted which allowed presentation of the findings at technical conferences and publication in relevant materials science journals. Consequently, knowledge capture and knowledge communication occurred in parallel and led to further application either within the university on new experimental campaigns, or through application of the research findings by the industrial collaborator or by another researcher at a different university.

 This example illustrates the highly non-linear nature of the knowledge process associated with university-industry research collaboration. The integrative model developed in this study can only be an approximation for this process although it does provide an overall framework to guide the knowledge-based activities. An alternative view would be to employ a system-of-systems approach (Keating et al., 2003) as a way of capturing the wider system of interest (WSOI) that can influence and contribute to the performance of the university-industry collaborative process.

Indeed research by Gandhi et al. (2009) has examined how different levels of flexibility for commercial outsourcing operations can be assessed using a system-of-systems approach. Other work by Philbin (2011a) proposed how system-of-systems mapping can support the planning process for infrastructure and engineering project management as part of a coordinated adoption of systems thinking within projects. These studies highlight the scope for using the system-of-systems framework to evaluate different management scenarios. Consequently, Exhibit 6 provides a system-of-systems map of university-industry research collaboration.

**Exhibit 6**. System-of-systems map of university-industry research collaboration.



 Viewing university-industry research collaboration as a system-of-systems highlights the complex nature of collaboration. Knowledge management strategy can be considered as one of the constituent systems within this view, where each of the four elements of the strategy (or subsystems) contributes to the performance of the knowledge management process that occurs as part of the collaboration, and the overall collaboration can be related to a range of related systems. There is the involvement of the collaborators themselves and the level of organisational learning that takes place, both within the university and at the company.

 In regard to implementation of the knowledge management strategy, there will also be social and cultural factors as well as the availability of IT systems and databases and research or project finances. All these systems will influence the adoption of a knowledge management strategy to support the collaborative process. Additional systems include emerging scientific areas, industrial technology trends as well as wider stakeholders, and these systems will still influence the system-of-systems but through varying levels of interconnectivity.

**Conclusions**

Developing research projects that both harness academic capabilities and address the identified industrial requirements helps to ensure the relevance of research whilst maintaining academic credibility. Establishing systems, such as laboratory information management systems for experimental data as well as other bespoke systems such as the balanced scorecard database, provide those involved with the collaboration the tools to collect and interpret both the findings of the research collaboration and monitor the progress of the programme that is funded by the company.

 Implementation of the balanced scorecard tool to support the collaboration was particularly successful in providing a knowledge repository to track the key knowledge based activities of the collaborative programme including those related to research and education. Initially when the tool was developed there was a degree of scepticism as to whether this approach would be effective and how the tool could be used to help manage the performance of the Institute. However, once the usefulness and availability of the information had been established then the tool was readily accepted by the technical and academic staff working on the programme. The industrial sponsor representatives also valued the scorecard as a convenient and accurate method to maintain an overview of progress across the full range of activities within the collaborative programme.

 The conceptual model developed in this paper provides a number of supporting initiatives and activities that may be undertaken within the four main elements of the knowledge management strategy. The case study has described how the knowledge-based activities have been pursued and this has included the management processes adopted as well as how the research and education activities have been configured. For example, the multidisciplinary research projects in shock physics that include joint academic and industrial supervision with the research findings being rapidly assimilated by the company through secondment of industrial science staff. Additionally the pursuit of initial experimental activities at the university to refine the range of materials under investigation whereupon more focused research was carried out at the company, highlighted the level of joint working as well as the trust that was established between the university and the company.

 Collaboration performance can be related to a broad range of determining factors and there will be a complex association between these factors. Consequently, viewing university-industry research collaboration as a system-of-systems has been advocated within this research study as this emphasises the non-linear nature of collaboration and the manner in which knowledge is acquired and ultimately applied. The exact interaction between the knowledge generation, capture, communication and application subsystems will be contingent on the circumstances of the collaboration as well as the supporting management processes, structures and roles of the parties involved. This paper has provided a commentary in order to help improve the understanding of the nature of the collaboration process and the collective manner in which the various knowledge based activities contribute to this overall process. Although it is recognised that additional research through process modelling is required in order to explore these interactions in more detail and to reveal greater insight into how university-industry research collaborations can be structured for success.

 Pursuing an integrative knowledge management strategy, which links together knowledge generation together with a complementary set of knowledge capture and communication activities, has provided a robust and systematic approach to ensure application of the arising knowledge application. In the case study, the industrial collaborator invested significant funding at the university with an intention to continue this funding into the long-term future. The ability for the programme to reach this sustainable level of funding has been associated with the effectiveness of the knowledge management strategy that was developed and adopted across the collaborative programme. A failure to design and implement the various complementary activities and processes that have resulted in benefits for both the university and company would have likely resulted in the collaboration not reaching this sustainable level of funding.

 The limitations of this study can be attributed to the qualitative approach employed and the use of reflective analysis by the author as part of a single case study investigation. However, this research includes a comprehensive literature review that draws on studies from both the knowledge management and university-industry collaboration arenas. The conceptual model builds on the literature through the analysis presented and the case study allows contextual examination of the strategies and activities that may be employed by practitioners across collaborations between universities and companies.

 Future work is suggested on applying the knowledge management strategy to different types of university-industry research collaboration. This should provide further insights into the merits and challenges of integrating the various knowledge-based activities to support the collaboration process. It is further suggested that quantitative metrics are developed to examine any resulting performance improvements for university-industry research collaborations.

**Acknowledgements**

 The author would like to acknowledge the support of colleagues from the Institute of Shock Physics at Imperial College London. Grateful acknowledgement is also made to the anonymous reviewer for helpful comments on the manuscript.

**References**

Abdullah, R., Selamat, M. H., Sahibudin, S. and Alias, R. A., “A Framework For Knowledge Management System Implementation In Collaborative Environment For Higher Learning Institution”, *Journal of Knowledge Management Practice*, March (2005).

Agrawal, A. “University-to-industry knowledge transfer: literature review and unanswered questions”, *International Journal of Management Reviews*, Vol. 3, No. 4 (2001), pp. 285-302.

Alavi, M. and Leidner, D. E., “Knowledge Management Systems: Issues, Challenges, and Benefits”, *Communications of the Association of Information Systems*, Vol. 1, Article 7 (1999).

Alavi, M. and Leidner, D. E., “Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues”, *MIS Quarterly*, Vol. 25, No.1 (2001), pp. 107-136.

Arntzen, A. A. B., Worasinchai, L. and Ribière, V. M., “An insight into knowledge management practices at Bangkok University”, *Journal of Knowledge Management*, Vol. 13 Issue 2 (2009), pp. 127-144.

Bayh, B. and Allen, J. P., “School Power: The Case for Keeping Innovation in the Hands of Universities”, *The Atlantic*, 11th April (2012).

Borghoff, U. and R. Pareschi, R., *Information Technology for Knowledge Management*, Springer-Verlag Berlin (1998).

Burnside, B. and Witkin, L., “Forging Successful University-Industry Collaborations”, *Research-Technology Management*, Vol. 51, No. 2 (2008), pp. 26-30.

Chesbrough, H., *Open Business Models: How to Thrive in the New Innovation Landscape,* Boston: Harvard Business School Press (2006).

Dwivedi, A. N., Wickramasinghe, N., Bali, R. K., & Naguib, R. N. G., “Designing intelligent healthcare organizations with KM and ICT”, *International Journal of Knowledge Management Studies*, Vol. 2, No. 2 (2008), pp. 198-213.

Edwards, J. S., “Knowledge management in the energy sector: review and future directions”, *International Journal of Energy Sector Management*, Vol. 2, Issue 2 (2008), pp. 197-217.

Gandhi, S. J., Gorod, A. and Sauser, B., “Effects of Outsourcing on the Flexibility Dynamic of **System** of **Systems**”, *Global Journal of Flexible* ***Systems*** *Management*, Vol. 10 Issue 1 (2009), pp. 33-40.

Holzner, B. and Marx, J., *Knowledge application: The knowledge system in society*, Allyn-Bacon, Boston (1979).

Kaplan, R. S. and Norton, D. P., “Putting the Balanced Scorecard to Work”, *Harvard Business Review*, Vol. 71, No. 5 (2003), pp. 134-147.

Keating, C., Rogers, R., Unal R., Dryer, D., Sousa-Poza, A., Safford, R., Peterson, W. and Rabadi, G., “Systems of Systems Engineering”, *Engineering Management Journal*, Vol. 15, No. 3 (2003), pp. 36-45.

Kirkland, J. “Towards an integrated approach: university research management in an institutional context”, *International Journal of Technology Management & Sustainable Development*, Vol. 4, Issue 3 (2005), pp. 155-166.

McAdam, M., Galbraith, B., McAdam, R. and Humphreys, P. “Business Processes and Networks in University Incubators: A review and Research Agendas”, *Technology Analysis & Strategic Management*, Vol. 18, No. 5 (2006), 451-472.

Moffett, S., McAdam, R., Parkinson, S., “Developing a Model for Technology and Cultural Factors in Knowledge Management: A Factor Analysis”, *Knowledge and Process Management*, Vol. 9, No. 4 (2002), pp. 237-255.

Nonaka, I. "The Knowledge Creating Company", *Harvard Business Review*, Vol. 69, No. 6 (1991), pp. 96-104.

[Nonaka](http://www.google.co.uk/search?tbo=p&tbm=bks&q=inauthor:%22Ikujir%C5%8D+Nonaka%22), I. and [Takeuchi](http://www.google.co.uk/search?tbo=p&tbm=bks&q=inauthor:%22Hirotaka+Takeuchi%22), H., *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*, Oxford University Press (1995).

Pentland, B. T. “Information Systems and Organizational Learning: The Social Epistemology of Organizational Knowledge Systems”, *Accounting, Management and Information Technologies*, Vol. 5, No. 1 (1995), pp. 1-22.

Philbin, S., “Process model for university-industry research collaboration”, *European Journal of Innovation Management*, Vol. 11, No. 4 (2008), pp. 488-521.

Philbin, S. P., “Design and implementation of the Balanced Scorecard at a university institute”, *Measuring Business Excellence*, Vol. 15, Issue 3 (2011), pp. 34-45.

Philbin, S. P., “Application of Systems Engineering and Systems Thinking to Project Management” in *Project Management (Construction Materials and Engineering)*, Ed. Collins, R. J., Nova Science Publishers: New York (2011a).

Philbin, S. P., “Resource-based View of University-Industry Research Collaboration”, *Proceedings of the PICMET'12 (Portland International Center for Management of Engineering and Technology) Conference, Vancouver, Canada* (2012).

Polanyi, M., *Personal Knowledge: Towards a Post-Critical Philosophy*, University of Chicago Press, Chicago (1958).

Rafols, I. “Strategies for knowledge acquisition in bionanotechnology”, *Innovation: The European Journal of Social Sciences*, Vol. 20, Issue 4 (2007), pp. 395-412.

Santoro, M. D. and Bierly III, P. E., “Facilitators of Knowledge Transfer in University-Industry Collaborations: A Knowledge-Based Perspective”, *IEEE Transactions on Engineering Management*, Vol. 53, No. 4 (2006), pp. 495-507.

Schultz, M. and Jobe, L. A., “Codification and tacitness as knowledge management strategies: an empirical exploration”, *Journal of High Technology Management Research*, Vol. 12, No. 1 (2001), pp.139-165.

Skyrme, D. J., ***You +1'd this publicly. Undo****Knowledge Networking****:*** *Creating the Collaborative Enterprise***,** Oxford: Butterworth-Heinemann (1999).

Spender, J. C., “Making Knowledge the Basis of a Dynamic Theory of the Firm”, *Strategic Management Journal*, Vol. 17, Special Issue (1996), pp. 45–62.

von Krogh, G., “Care in Knowledge Creation”, *California Management Review*, Vol. 40, No. 3 (1998), pp. 133-153.

Wiig, K. M., “Knowledge Management: An Introduction and Perspective”, *Journal of Knowledge Management*,” Vol. 1, Issue 1 (1997), pp. 6-14.

Zack, M. H., “Managing Codified Knowledge”, *Sloan Management Review*, Vol. 40, No. 4 (1999), pp. 45-58.

Zheng, W., Yang, B., McLean, G. N., “Linking organizational culture, structure, strategy, and organizational effectiveness: Mediating role of knowledge management”, *Journal of Business Research*, Vol. 63, Issue 7 (2010), pp. 763-771.

**About the author**

Simon P Philbin is Associate Director of Enterprise Projects at Imperial College London in the United Kingdom and Visiting Fellow at Imperial College Business School. In his current role he directs corporate development projects across the university and prior to this he was the founding Programme Director of the Institute of Shock Physics at Imperial. He holds a PhD (Brunel University) and BSc (University of Birmingham) both in Chemistry and an MBA with Distinction (Open University Business School). Dr Philbin has authored/co-authored over forty journal and conference papers across several areas including project management, systems engineering, university-industry research collaboration, and chemistry. He is the recipient of the Merritt Williamson best conference paper award from American Society for Engineering Management (ASEM) as well as both the Rod Rose best journal paper award and best annual symposium paper award from the Society of Research Administrators (SRA) International.