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Technology Transfer Projects in the UK:
An Analysis of University - Industry Collaboration

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ABSTRACT

This article examines how technology transfer has operated in university-company projects undertaken in small to medium sized enterprises via the UK Knowledge Transfer Partnership scheme. It adopts a qualitative case study approach, focusing on three companies drawn from an initial review of fourteen technology transfer projects. This provides the foundation for the development of a model of 12 key factors that underpinned successful outcomes in these projects. The fourteen projects are reviewed in terms of their impact on either process change, service improvement or product development, drawing upon the post-project assessments of the funding body and the developed model. Findings suggest that using new technology to innovate internal processes and services is likely to prove more successful than projects focusing on new product development. The model provides an analytical framework that will be of interest and value to academics and business practitioners looking to develop university-industry partnerships involving technology change and innovation.

KEYWORDS

Analytical Model, Case Studies, Knowledge Transfer Partnerships, Knowledge Transfer, Project Management, Technology Innovation, Technology Transfer, University–Industry Linkages

INTRODUCTION

Since the turn of the century, technology transfer and innovation have played an increasingly important role in UK government policy for re-invigorating and supporting British industry, and technology transfer from third parties such as universities can act as a catalyst for achieving increased competitiveness, particularly for small to medium sized enterprises (SMEs). This paper examines how such technology transfer projects have been undertaken under the auspices of the UK Government's Knowledge Transfer Partnership (KTP) scheme. The research focuses on three technology transfer case studies to establish the key factors that determined the success or failure of these projects, and to examine how new technologies were introduced to promote innovation in internal processes, in services to customers, and in new product development. The paper also looks at a wider range of KTP projects to assess the relative success of innovation in these three operational domains.

A lack of financial resources and basic technological capability can act as barriers to SMEs adopting new technologies, both for their in-house systems or in the incorporation of new technologies into their products or services provision (Guzzini & Iacobucci, 2017). Brychan (1999) underlined

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the importance of technology transfer networks for SMEs, particularly those where technology is transferred into an SME from an external source, and the term "open innovation" was first used by Chesbrough (2003) to denote the use of external resources as part of the research and development process for new technology. This gave impetus to the harnessing of external capabilities to achieve swifter and more effective results in the application of new technologies in industry. However, related research has often focused on larger companies, and "small and medium-sized enterprises are excluded from the mainstream discussion on open innovation" (Brunswicker & Vanhaverbeke, 2015, p.1241).

The focus of this paper is the operation of the KTP scheme to facilitate technology transfer in SMEs. In the following section, a brief overview of the KTP scheme is provided, followed by a review of relevant literature, models and concepts and positioning of two research questions. The research methodology is then outlined, and the selection of the case studies is discussed. The next section presents the three in-depth case studies, providing the basis for the identification of key factors that underpin successful technology transfer projects in this context. These are discussed in the penultimate section, which addresses the research questions. Finally, the conclusion pulls together the key themes of the paper and discusses the contribution and potential of the model.

THE KNOWLEDGE TRANSFER PARTNERSHIP SCHEME

In the same year that Chesbrough discussed and defined the open innovation concept, the UK Department of Trade and Industry (DTI) specified a range of products for promoting and enabling knowledge transfer and innovation, in particular to support technology transfer to SMEs (DTI, 2003). One of these products is the KTP scheme, which provides direct financial support for graduates to undertake specific technology transfer projects in firms of all sizes, but particularly in SMEs, which are defined in a European context as having less than 250 staff (European Commission).

Interest in technology transfer, and more generally knowledge transfer (KT), and its role in promoting economic growth and job creation has been growing for over two decades in the UK. Hardhill and Baines (2009, p. 82) noted that "since 1993 the promotion of knowledge transfer to maximise public investment has been a recurrent theme in UK policy documents", and the Lambert Review of Business-University Collaboration acknowledged the scale of public investment on teaching and research within the UK's universities, and formally endorsed the belief that "transferring the knowledge and skills between universities and business and the wider community increases the economic and social returns" (Lambert, 2003, p. 31). More recently, the Sainsbury Review of the UK Government's Science and Innovation Policies identified "knowledge transfer activity as an important way to make the most of publicly funded research and to increase innovation in business and public services" (Department for Innovation, Universities and Skills, 2007, p. 60). In particular, the review recommended greater government financial support for business facing universities and increasing the number of KTPs.

The KTP scheme provides government funding to enable organisations to take advantage of the wide range of expertise available from within universities. Essentially KTPs can be viewed as a four-way partnership between the university, the company, the graduate (or "Associate" as they are termed) and the UK Government, which provides up to 67% of the funding for the project. The partnerships involve the Associate working in an organisation full time, for a period of between 6 and 36 months, but two years is the normal duration of these projects. During this time, a university academic (the "academic supervisor") is assigned for 25 days per annum to support and supervise the project, and to bring in specialist knowledge and expertise as appropriate to ensure project delivery. In addition, the university provides an academic to oversee and generally manage the project from the university side (the "academic lead"). These two roles can be fulfilled by the same person. Training and equipment are also provided, and the total value of the scheme to the SME is circa £65K–£70K per annum. A number of benefits for the company partner can result from involvement in a successful KTP,

including the professional development of its staff, skills enhancement and embedding, organisational development and innovation in processes, services or products.

There are also many benefits for the partner universities, both to the institution and to the individuals involved in the projects; but the focus in this article is mainly on the impact these projects can make in terms of using technology transfer as a catalyst for innovation in the partner companies. Innovate UK (formerly the Technology Strategy Board), the main UK Government agency responsible for KTPs, has stipulated that it wishes to focus its funding primarily on supporting SMEs in various aspects of innovation, especially those emanating from technology change and competency development. Since 2003, the Gross Value Added by the University's 45 KTPs was £4.1 million (Biggar Economics, 2015), and an increasing number of SMEs have embarked upon KTP projects, attracted by the possibilities of growth and innovation in their operations and processes.

The funding body for KTP projects also provides a post-project assessment of the project outcomes, providing an A-E grading. This is discussed further below, but we note here that no detail is given of the rational for this assessment, that might highlight key issues or lessons that could be learnt for the future. The model developed through this research attempts to plug this gap.

LITERATURE REVIEW

For all sizes of organisations, the external environment for technology is rapidly evolving, requiring regular upgrades to information systems and technical infrastructure and adjustments to future IS/IT strategies. Technology transfer involving support from third parties is one way of achieving this, but technology transfer is not a straightforward process. Boseman (2000, p. 627) suggests that "anyone studying technology transfer understands just how complicated it can be. First, putting a boundary on 'the technology' is not so easy. Second, outlining the technology transfer process is virtually impossible because there are so many concurrent processes. Third, measuring the impacts of transferred technology challenges scholars and evaluators, requiring them to reach deep down into their research technique kit bag". This article discusses the introduction of new technologies into companies partnering with the University of Gloucestershire within the framework of the KTP scheme. However, the technology in question is not transferred from the university, nor was it developed within the university. Rather, the skills and expertise from university staff are used to lead and manage the introduction of new technologies in the partner companies. It thus falls within Roessner's (2000) conceptualisation of technology transfer as the movement of know-how, technical knowledge, or technology from one organizational setting to another. These projects involve the transfer of know-how and technical knowledge, which is then used to introduce new technologies, either co-developed with the partner company or acquired via other third parties. We thus use the term "technology transfer project" in this article, with the qualification that the transfer is more about knowledge, know-how and experience relating to technology, rather than the technology itself.

There is a clear link in the literature between knowledge management and technology transfer. For example, Rafiei, Akhavan and Hayati (2016, p. 178), in their study of the Iranian aerospace industry, found that "there is a significant and positive relationship between knowledge management and successful technology transfer effectiveness. Further, relational and organizational capabilities - as key factors and facilitators - play a mediating role between knowledge management and technology transfer effectiveness". This is reinforced by Nahar, Al-Obaidi and Huda, (2001, p. 356) who concluded that "in most cases, the transfer of technology requires the transfer of knowledge related to physical process contained in physical elements (e.g. computer) as well as the knowhow related to operating them". Nevertheless, Marouf and Khalil (2015), point out that "the knowledge management (KM) literature in general is short on field evidence concerning knowledge sharing (KS) practices in project management settings, where knowledge occupies a central place".

Technology transfer will normally involve innovation to some degree, and "cooperation between industry-university can increase in a significant way the capability of enterprises' innovation" (Silva,

Gaia, Caten, & Facó, 2017, p. 49). Gloet and Samson (2016, p. 55) researched the relationship between innovation and knowledge management and concluded that "the management of knowledge may indeed hold the key to increasing systematic innovation capability in organizational contexts", and that "for managers, this involves developing new forms of knowledge, embedding this new knowledge within organizations, as well as managing flows of information, knowledge and experience".

There is a common distinction in existing literature between radical innovation and incremental innovation. The former normally involves the introduction of fundamental changes, often in the technology sphere, that are linked to a company's long-term business objectives, and often take many years to fully materialise and deliver expected benefits. Indeed, Pedersen and Dalum (2004) suggest that this often represents a new technological paradigm. Incremental innovation, on the other hand, though it may well involve the application of new technology to deliver significant organisational benefits, is normally delivered within a 6-24 month period, and this aligns with the technology change introduced in the KTP projects. Urabe (1988, p. 3) defines innovation as "the generation of a new idea and its implementation into a new product, process or service". Similarly, Popadiuk and Choo (2006, p. 309) suggest that "innovation consists of new ideas that have been transformed or implemented as products, processes or services, generating value for the firm".

Other authors (Lichtenthaler, 2011; Robertson, Casali, & Jacobson, 2012) have concluded that external knowledge sourcing requires certain internal capabilities for the effective integration and application of new knowledge. Brunswicker and Vanhaverbeke (2015, p. 1242) suggest that "so far, little is known about the role of such integrative managerial practices for innovation in external knowledge sourcing in SMEs". Alvarez and Iske (2015), in their study of 142 Dutch SMEs, empirically analyse possible complementarity or substitutability between internal capabilities and external knowledge sourcing. Their findings "suggest a negative interplay between internal capabilities and external knowledge sourcing" (Alvarez & Iske, 2015, p. 55). Chesbrough (2003) differentiated between two concepts of open innovation: inbound, where new ideas flow into an organization, and outbound, where internally developed technologies and ideas can be acquired by external organizations. As noted by Brunswicker and Vanhaverbeke (2015, p. 1243), "to successfully benefit from inbound open innovation, a firm requires some higher-order management capabilities to align inbound knowledge flows with the firm's in-house innovation activities". Guzzini and Iacobucci (2017) analysed the factors affecting the likelihood of the failure of innovation projects, and the relation between project failure and innovation performance. Based on data from German firms in the period 2002–2005, they highlighted the significance of collaboration with universities and public research institutions.

This research identifies the key factors that enabled the successful completion of technology transfer projects within the management and financial framework of the KTP scheme. It builds on some models in the extant literature – for example, the five-stage Innovation Capability Maturity Model (ICMM) model of Essman and Du Preez (2009), and its subsequent development by Enkel, Bell, and Hogenkamp (2011), who identify three main elements that determined the successful completion of change projects. In their model, the three main elements are Climate for Innovation (covering sub-elements such as clarity of strategy, initiative taking, and clear target assessment), Partnership Capacity (sub-elements of partner satisfaction, network building and diversity in collaboration) and Internal Processes (communication, innovation facilities, knowledge sharing). Based on the detailed analysis of the KTP case studies, this paper builds on these concepts to develop a new model of twelve change factors that can be used to assess the readiness of SMEs to successfully pursue technology transfer projects.

The resultant model will help fill the gap in the existing literature identified by Filippetti and Savona (2017) when referring to University-Industry (UI) linkages. They suggest that "it is widely recognized that universities and other public research institutions play a central role within systems of innovation for basic research generation, technology transfer and knowledge diffusion to firms", but nevertheless "the analyses of factors that slow down or hamper cooperation have been rather overlooked" (Filippetti & Savona, 2017, p. 720). In the KTP scheme, the funding body (Technology

Strategy Board, now renamed Innovate UK) give an assessment of each project after project closure. They rate each project on an A-E scale (A being very good, and E being unsatisfactory). They base this on the confidential project-end report from their regional representative, who attends the quarterly Project Board meetings at the KTP companies, and the Final reports from the University and Company, and also the Associate. However, no explanation of this rating is given. Indeed, in the wider context of technology transfer and innovation, Enkel, Bell, and Hogenkamp (2011, p. 1162) have noted that "we still lack a clear understanding of these mechanisms and how we can gain maximum advantage from this approach". To help redress this imbalance, this paper addresses the following research questions:

1. What key factors determined the success or failure of technology transfer projects undertaken within the framework of the KTP scheme?
2. Was technology transfer more successful in innovating internal processes, improving service provision or developing new products?

RESEARCH METHODOLOGY

The case study method is a well-established approach to research, particularly qualitative research, and this paper analyses three KTP projects in detail to explore how the introduction of new technology was used to innovate processes, services or products. These are qualitative case studies, which may be used to develop theory as a result of data analysis (Saunders, Lewis & Thornhill, 2009). They allow a "detailed investigation of one or more organisations, or groups within organisations, with a view to providing an analysis of the context and processes involved in the phenomenon under study" (Hartley, 2004, p. 323). Case studies "…allow for more in-depth analyses and provide the opportunity to place research into a certain context due to the selection of specific sectors, institutions, countries, etc…" (Cunningham, Menter, & Young, 2017, p. 923). One of the main strengths of this approach is its depth, and the amount of detail it can generate. The benefits of such qualitative research were highlighted by Silverman (2013), who noted that case studies provide a complex and rich understanding of change projects across a period of time, thus allowing for an understanding of causality and history, set in a local context.

In these case studies, several different methods were used to collect data, all of which are associated with a qualitative approach, including documentation analysis, observation, and interviews. Main documentary sources were the original project proposals, written in conjunction with the company managers who then directed the project and chaired the weekly project review meetings; the minutes of these weekly review meetings; the three monthly Project Board meetings held with the local representative of the UK government's funding body; the project final reports, one authored by the Associate and the other jointly by the academic supervisor and company management; and the many emails sent and received across the duration of these projects and beyond. These provide a rich source of information that helped identify the key factors in each case study. Participant observation by the academic supervisor has also contributed to the interpretation of events, evidenced both in the formal meetings noted above, but also in the many informal discussions with the Associates and company managers. This provided a deeper understanding of key project issues and why and how decisions were made. Walsham (1995, p.76) notes "it is desirable in interpretive studies to preserve a considerable degree of openness to the field data, and a willingness to modify initial assumptions and theories. This results in an iterative process of data collection and analysis, with initial theories being expanded, revised, or abandoned altogether".

Yin (2012) argued that selection of multiple cases should consider a similar context so that a set of multiple facts could be more easily identified. He suggested that the more the cases, the greater confidence or certainty in a study's findings, and the fewer the cases the less confidence or certainty. The research philosophy contains important assumptions about the way the researcher views the world

and therefore influences the research strategy and methods. The research philosophy in this research can be characterized as interpretivist, based on an inductive approach.

Of the forty-five KTP projects completed by the University of Gloucestershire with partner organisations since 2003, fourteen projects involved the introduction of new technology in SMEs, in which the author was academic lead and/or academic supervisor. These projects are listed in Table 1, indicating date of project and headcount and turnover at the commencement of the project. They are from a wide range of industry sectors, and, prior to project commencement, their use of technology was generally at a low to medium level, as defined by Alvarez and Iske (2015). The technology transfer focus in each company is also shown in Table 1, relating to process change (Pc), service improvement (Si) or product development (Pd). The majority of these projects were concerned with using new systems and other technologies to improve internal processes. Following the initial review of these fourteen projects, three cases were chosen for more detailed examination, one from each of the focus areas (i.e. Pc, Si or Pd), to establish what were the key factors in determining the outcome of these technology transfer projects. The three in-depth case studies are with Optimum Consultancy Services (OCS), Brecon Pharmaceuticals (BP) and E-Business Services (EBS) and exhibit very different company profiles. These are all real case studies, but the last named is an alias (as are the customers mentioned in that case study) because of confidentiality issues.

OCS, based in Cheltenham, Gloucestershire, was formed in 2008 through the merger of two companies - Hama Ltd, a project management services business, and J. Orchard Consulting Ltd, a surveying services business. In its first trading year (2008-9) the new company achieved a turnover of £2.4m and had 35 staff. Its core business is project and cost management in the property, engineering and construction fields, and its customer base includes major retailers, rail operators, major financial

Table 1. SMEs undertaking technology transfer projects

Company Name	Industry Sector	Focus	Project Duration	Staff	T/O (£m)	Rating
Allpay.net	Financial technology services	Pc	2007-9	190	21.8	B
AuraQ	Process management software & services	Pd	2009-11	5	0.5	D
Beacons Business Interiors	Office design	Pc	2004-6	47	6.9	B
Brecon Pharmaceuticals	Pharmaceutical packaging	Si	2004-6	231	7.6	B
Building Solutions	House builder	Pc	2005-7	75	5.8	C
C&G Services	Training services	Pc	2005-7	25	1.2	C
E-business Services	Web based software developer	Pd	2006-8	6	0.2	C
Energist UK	Environmental consultancy	Pc	2010-11	40	1.1	D
Fixing Point	Roofing materials manufacture	Pc	2006-8	53	5.4	B
Matchriver	Software solutions	Pd	2006-7	8	0.5	E
Muddy Boots	Supply chain software	Si	2010-12	30	1.3	C
Optimum Consultancy Services	Project management services	Pc	2008-10	35	2.4	B
Pegasus Retirement Homes	House builder	Pc	2003-5	39	10.4	B
TPG DisableAids	Equipment for elderly & disabled	Si	2009-11	47	4.3	C

Note: The third column indicates a focus of process change (Pc), service improvement (Si) or product development (Pd) for the technology project. The right-side column (rating) indicates post-project grading by the funding body.

and banking corporations and sustainable developments. The KTP project concerned process innovation, achieved through the introduction of new information systems.

In contrast, BP provides outsourced services to the pharmaceuticals and healthcare industries, principally the packaging of manufactured drugs and of new drugs undergoing clinical trials. The company's reputation was founded upon a high quality, flexible service, embodied in its vision statement of the time - "Growth through Excellence" – which "places great emphasis on the desire to provide a high-quality service which sets the standard against which our competitors are judged" (Momenta, 2005, p.2). At the start of the project in 2004, the company, based in Hay-on-Wye, on the Wales-England border, had 231 staff and a turnover of £7.6m, but was targeting a tripling of revenues to £22m by 2007. Here, the technology transfer was to support a major change in service delivery, achieved through the installation of new laboratory hardware and support infrastructure. Finally, EBS was, in 2005/6, a software house generating revenue from the delivery of bespoke and packaged web-based products, with the bulk of company turnover coming from the sale of its web product, which was used by client companies as an intranet, information portal and communications management tool with their end customers. EBS is a micro company of less than 10 staff, based in Hereford, Herefordshire. The technology transfer focused on the development of a new technology product, using web-based software tools.

CASE STUDIES

New Information Systems and Process Change at Optimum Consultancy Services (OCS)

Following the creation of the newly merged company in 2008, an internal review of systems and processes highlighted the challenge of combining and upgrading two different technology architectures and in particular to align and standardise the sales processes across three offices. The existing systems had been acquired and set up in an *ad hoc* manner whenever a need arose. Separate software and hardware systems had been purchased without detailed analysis of their longer-term implications for IT strategy and process performance. Time lapses in distributing documentation were causing real risks on projects as there was no single source of project documentation which could be accessed by everyone in the company. The expanding network filing systems, delays in the sharing of project information, finding the right electronic version of a document on the company networks, were all of major concern.

New integrated systems and customer facing processes were needed to provide infrastructure support for steady growth and improved margins, without the stop-start addition of administrative overheads. In addition, there was an urgent requirement to implement a refreshed and refocused business development strategy that crystallized the different roles of the three OCS offices (Cheltenham, London and Haywards Heath). The project was therefore focused on introducing new technology to effect process change. In terms of hard bottom-line benefits, the objectives were to reduce general administration time by 25% (used in searching for documents and data re-keying), and thereby improve efficiencies in reporting, forecasting, monitoring and controlling.

The project was divided into distinct stages and project managed using selected elements of a mainstream project management methodology. This brought a disciplined approach to the acquisition and implementation of packaged business software. Initially, high-level business process mapping was carried out to develop a better understanding of Optimum's core processes and to generate ideas for process improvement, highlighting information bottlenecks, data duplications and process delays or malfunctions. Analysis of the current systems used by the company was carried out and overlain on a process map, and key users from all three offices were interviewed to establish current and future information needs.

This analysis revealed the disparate, non-integrated nature of existing systems (despite the fact that most processes were closely interrelated with each other). Existing workflows around the main

systems still involved a significant amount of manual intervention. For example, the Sage software package was used by the finance department for sales order processing and invoicing, but it was not linked with systems used in the project management function.

After an evaluation of a number of packages available on the market, a web-based enterprise portal solution was recommended to the Project Board to provide an integrated collaborative environment for all business processes and to streamline the process flow across the three offices in different locations. The decision to proceed with off-the-shelf packaged software, implemented on on-premises servers, was taken and the suitability of collaboration software solutions available in the market was assessed. The initial list of potential suppliers was compiled from current enterprise portal software available in the market, which comprised the features of Document Management, Customer Relationship Management, Project and People Management. The initial software supplier responses were evaluated using points scoring criteria and score card. From this evaluation, three suppliers with the highest scores were invited to the second round of evaluation, when a similar method was used to evaluate the suitability of software. At the end of this phase, the software package with the highest score was selected – Workspace from Union Square.

The initial implementation (Phase 1) addressed the key business areas of document control, contacts and access to enquiry and project information. Phase 2 focused on integrating Optimum's finance operations into the Workspace software package. The company embarked on an internal communications exercise via company meetings and newsletters to ensure that everyone was aware of the project and its impacts and implications. Other activities during this period included unit testing of the main software modules, data migration of existing files and documents from the two old servers to the central server. Follow up sessions with users were carried out periodically to reinforce training and ensure that the full benefits of the new software solution were being realised. The system was formally handed over to the company IT staff in June 2010.

The new systems allowed resource scheduling by field-based project managers, and the coordination of a range of activities carried out by architects, designers and surveyors. The project was a key enabler of continued growth and essential to the efficient operation of the company's core business. The lack of sound systems had meant administrative and management staff had been drafted in on an *ad hoc* basis to support the delivery of key projects. This produced fluctuations in turnover, profit and staffing levels.

Management of projects was made more efficient through the new technology. A bid having been won, all information was now ready to be automatically transferred to the project record, ensuring continuity and reducing errors; and the ability to find things more quickly proved increasingly useful as projects progressed. The new collaboration software integrated the management of time and resources and the recording of skills and training into the mainstream corporate database. Benefits included having instant access to forward schedules and availability without reliance on monthly paper/spreadsheet reports, which had proven very difficult and time-consuming to maintain in the past. The new system came to play a significant role in business development, keeping track of sales enquiries. Any work done on prospective jobs is able to be kept in the system. This allowed the senior management team to track and manage the new work pipeline more easily.

The ability to access information instantly about overall company performance, forward workload and future prospects as well as full details for every job - including who is looking after it, the client, fee type, value, allocated costs and the margin that is being achieved - greatly improved efficiencies in many business activities. In addition, the project "provided the company partner with the experience and know how to effect cultural change in the organization. This is perhaps the most telling benefit long-term as it will help the company to continue to evolve and develop" (Technology Strategy Board, 2010, p.3).

Quantifiable benefits included a range of efficiency savings. "It is estimated that 5% of working time was previously wasted due to inefficient IT systems. Removing this waste contributes circa £60K per year savings. Avoidance of additional administrative headcount provides an additional saving

of £35K per year per headcount" (Technology Strategy Board, 2010, p.3). Based on the bottom-line benefits noted above (£95K p.a.), "…the project has a payback period of just over one year, given the initial investment in software, hardware and staff of circa £110K in the two-year implementation period. This is in excess of original expectations…" (Technology Strategy Board, 2010, p.3). Since the close of the project, the company has continued to be profitable, and in 2017, the Union Square software is still central to company operations.

New Laboratory Services at Brecon Pharmaceuticals (BP), Hay-on-Wye

In 2004, when the project started, BP were providing a range of outsourced services to the pharmaceutical and healthcare industries, principally the packaging of manufactured drugs and of new drugs undergoing clinical trials. In both these instances, the drugs had to undergo a range of laboratory tests. Until 2004, BP had itself contracted out this part of their service to third parties. However, to support their growth plans, the company took the view that clients would in future prefer to place both their packaging and analytical needs with one company, and therefore consider bringing projects to BP that would otherwise have gone elsewhere.

The objectives of the project were thus to establish a state of the art analytical laboratory to undertake routine analysis and associated testing for BP's current and potential client base. The company wanted to develop a centre of excellence for laboratory information, statistical analysis and analytical testing, involving a new laboratory information management system (LIMS) which would be linked to their newly installed Enterprise Resource Planning (ERP) corporate system. The project would research client requirements for analytical services and develop a new revenue stream from additional analytical work, targeting a £500k per annum revenue increase by 2008. The KTP project focussed on the introduction of new laboratory equipment and associated systems to provide in-house testing for its clients. As such it used new technology to innovate its service offering in this field.

The project team were assembled in early 2004, and embarked on a five stage project that completed in March 2006. Stage one involved the research of regulatory requirements and their implications for the client base, and an assessment of the potential new business opportunity. The current and future legislative guidelines for stability and validation testing in the UK, EU and USA were identified and assessed, as was the existing and forthcoming legislation and regulatory frameworks for the clinical trials/laboratory testing sectors. Client requirements for analytical services were also explored at this stage and forecasts made of potential new additional revenue from the new client base.

A piloting of new laboratory equipment was then undertaken, and relevant configurations and space requirements were identified. Based on pilot results, an equipment short-list was drawn-up with space/facility implications, and procurement of a range of equipment followed. This included high pressure liquid chromatography, ultra violet/infrared scanners, and dissolution, Karl Fisher and disintegration units. The initial set-up and training on new laboratory equipment followed, and for each of the main equipment types, user requirements (as in the specification) were confirmed, Installation Qualification documents written, and Operational Qualifications documented. Standard Operating Procedures for routine use were also drawn up. An interim data storage and analysis tool for analytical data was developed in Microsoft Excel software. Stability incubators, for testing the stability of compounds over time, were installed for use in conjunction with the laboratory equipment.

The new in-house laboratory was ready for commercial packaging and clinical trials operation in 2005. Sampling and testing of clinical and commercial products in accordance with agreed procedures and protocols was undertaken. Laboratory performance and customer responses were reviewed and approaches and techniques refined. An information systems review was undertaken in parallel, leading to the migration of laboratory data into a Microsoft Access database. The project was completed in early 2006.

The creation of the laboratory resulted in new projects coming to Brecon. Some clients required analysis prior to importing products into the EU. Other clients required analytical testing before exporting products outside the EU. Brecon rapidly developed links with companies requiring testing

for import, export and the internal EU market. This included knowledge and expertise in process control equipment, laboratory technologies and test equipment and project management skills in the development and implementation of new technologies. The company also improved the scope of assessment systems for chemicals used on site (in compliance with the Control of Substances Hazardous to Health Regulations, 2002) and acquired expertise in generating method transfer and stability reports to meet expectations of varied international clients. The laboratory represented an entirely new function which broadened the services the company could offer. The potential to win more and varied projects was enhanced and the company could offer clients improved flexibility to meet their variable analytical needs and priorities. In the broader financial context, BP continued to grow its turnover from £10.2m in 2004 to £12.9m in 2005. The new laboratory had become a key strategic service to support and promote increases in turnover and profit.

Prior to the start of the project, the outsourced laboratory costs to BP were running at £100K per annum, and were projected to rise to over £250K in 2007 as the company's business grew. "Not only has this cost been saved, but new additional analytical contract sales are estimated to bring the total revenue gain (saving on outsourced costs plus new sales) to £847K by 2008. The project has generated additional income as a one-off service, competing with the laboratory contract companies BP had previously used itself" (Technology Strategy Board, 2007, p.3). This new revenue stream generated an additional £151K per annum in BP's financial year 2005, and two significant competing contract analytical laboratories ceased to offer an analytical service since the BP laboratory came into operation. "Brecon is well positioned to benefit from this reduction in competition" (Technology Strategy Board, 2007, p.3).

In March 2006, the company was bought by the American international pharmaceutical services company AmerisourceBergen, to act as its hub for European operations. The company doubled the size of its operations by expanding the manufacturing, packaging and warehousing facilities in Hay-on-Wye. The expansion was prompted by a growth in the demand for the company's clinical trial supply and commercial packaging services, including the in-house laboratory services. An additional 115 staff were recruited and the company now has in excess of 300 employees.

New Web-Based Products at E-Business Services (EBS), Hereford

In 2006/7, EBS initiated a new business plan to move away from purely bespoke adaptations of their existent information portal product (Woolpack), towards a company specialising in custom-built web portals for key customers running Microsoft Dynamics (previously called Navision) as their core back-bone system, especially in the financial and related service sectors. The project "was key to implementing this business transition as it delivered the first attempts at design and development of web portals in this niche market" (Technology Strategy Board, 2008, p. 2). This project aimed to use new technology developments to innovate the company's product offering.

EBS had worked for a number of years for Skindal Life, who sold through financial services companies with many branches around the UK. They were viewing the possibility of sharing data with other parties when they entered into new partnerships with a number of other well-known financial services institutions. These partners sold products administered by Skindal Life through their established adviser channels; however, the partners wanted their advisers to access these plans through their web site. In addition, to attract potential new investors, the solution needed to have the capability for "fund supermarket" trading.

The new web-based product involved a highly secure architecture. Users from partner sites were directed to Skindal Life's website, using the partner's authentication, so users did not have to re-login. Users were able to transparently access pension data held in the Skindal Life back office systems. As they accessed the web pages they were dynamically branded. The net effect was that the partners' investment was minimised, but they gained access to the full product functionality. Once access to the site was provided, partners and advisers were able to view all their plans administered by Skindal Life. Advisers could additionally buy and sell unit trusts online, through a real time web

service connection into a fund supermarket. Data was exchanged between the website and their back office systems (Microsoft Dynamics-Navision). All exchanges were performed securely via web services using XML.

Strategically, Skindal Life was able to open new distribution channels, offering its services through partners. Additional business was achieved without an exponential growth in headcount. Operationally, Skindal Life provided access to their plan data through these channels in a way which simply could not have been achieved without the use of the internet; and the business partners shared the benefit of Skindal Life's web services, without having to replicate the functionality themselves. Advisers had the additional benefit of being able to access information 24/7. Skindal Life witnessed increasing volumes of web-based enquiries, as well as greater use of the online fund supermarket dealing service. The company were able to handle significantly increased volumes of new business, whilst continuing to provide their award-winning high quality service.

Building on the experience at Skindal Life, the new web portal and middleware products were further deployed at a second customer – Effective People Management (EPM). EPM provide personnel services, consultancy and training to a large number of Primary, Secondary, Special, Foundation, Aided and Community schools and Academies. EPM had extensive expertise, experience and understanding of personnel issues in schools who they helped to achieve the high level of staff management necessary for running a successful school. EPM provided these services to hundreds of schools across the UK, ensuring tens of thousands of education sector employees were paid timely and accurately every month. EPM concluded that these working practices could be greatly improved with the use of the internet, and, using EBS's new products, a new e-business strategy was developed to facilitate access to EPM's services over the internet via a secure portal enabling the schools to maintain and view their information in EPM's back office systems.

The portal was a secure, confidential web site only accessible by the head teacher and authorised staff in each school. To use the site, schools were required to follow a quick and simple registration process to ensure that only authorised users had access. The project went through the normal development life cycle, with the Associate documenting and analysing EPM's requirements and developing a functional specification in mid-2007. The web portal was developed using .Net technologies and installed using EBS's Message Broker service for SQL Server 2005. Key features of the new web portal included the ability to submit, view and amend details of new employees and their contracts, submit overtime for staff and expenses for payroll, confirm absence due to sickness and holiday and view employees' payslips and P60 forms. The schools also benefited from having greater visibility of, and 24x7 access to, their school specific information, including statutory required information.

EBS established "a foothold in the web portal market linked to Microsoft Dynamics" and it was "expected that this type of development will provide a major income stream in the coming years" (Technology Strategy Board, 2008, p.2), and indeed this development and its successors and variants have contributed to the continued growth of the company. Key to the success of the developments at Skindal Life and EPM was an early understanding of the potential role of "middleware" software in client companies' information systems architecture. An important issue for many service companies is that their core corporate data is held in internal software packages and is often not readily available to business partners via their websites. Companies in this sector thus tended to have problems with systems integration and often resorted to third party "middleware" products to link systems together. These products have since emerged as being very significant in overall systems strategy. They generally have no direct user interface for the end-user, but act as a funnel for the transport of information between applications and provide a key link mechanism between the web-based portal and in-house information sources. The new web portal products used leading mainstream technologies - ASP. net, VB.net and SQL Server 2005. Technology transfer was multi-faceted and at various levels, supporting the company's new strategic direction, and providing the Associate, who gained his Microsoft Technical Certified Specialist (MCTS) qualification in the course of the project, with a new career path.

ANALYSIS

This section reflects on the initial research questions and addresses them in light of the case studies and factors emerging from them as critical to project success.

What Key Factors Determined the Success or Failure of Technology Transfer Projects Undertaken Within the Framework of the KTP Scheme?

Certain factors emerge from the three case studies as being of particular significance in facilitating successful technology transfer in these projects. These factors can be grouped into three categories: factors directly relating to the technology itself, factors relating to the skills and competencies of the people involved in these projects, and factors concerning the nature of processes and process change in the company.

As regards *technology*, a number of factors were of particular importance in underpinning successful project outcomes. Specifying exactly what was needed in a structured and well communicated manner was a key pre-requisite. This was particularly in evidence at OCS (for new software packages) and at BP (for new laboratory hardware and software), providing a clear framework for the technology transfer process. An effective selection and fit of new technologies to accord with these requirements was also an important factor; this was evident in all three cases, but notably at EBS where the application of new web-based tools and programming languages supported the development and delivery of new solutions for key customers that allowed a step change in their use of the internet for customer facing processes. Execution of the project plan was done efficiently and effectively to time and budget, using appropriate project management methods in all three projects; and the handover of project and technology knowledge was of significance in allowing the continuing successful use of new technologies. At EBS, for example, "the overall upskilling of staff to use .Net and other new technologies" was seen to "help its competitive position" (Technology Strategy Board, 2008, p.5). This was done within the project duration through the structured programme of weekly project meetings and related workshops; and at OCS, this continued post project as the Associate was employed within the company as IT support manager.

In terms of people skills and competencies, project leadership from senior company personnel was a key factor in all three cases. At both OCS and EBS, the managing director chaired the weekly project management meetings as well as the three monthly project reviews with government sponsors. At BP, the laboratory manager undertook the same role. The direct involvement of these personnel ensured the projects were kept high on the business agenda in all three companies and provided key inputs to decision making and problem resolution. This also provided an appropriate environment for initiative taking by project team members. Aligned with this was the project management experience and capability of the Associates and academic supervisors that kept the projects in line with original specifications and provided additional project documentation. This was particularly in evidence at OCS, where the Associate was a qualified project manager and the project was tightly defined in a Project Brief document. In all three cases, the academic supervisor was also a qualified project manager with relevant experience of technology management in industry.

All three cases involved a closely-knit project team, led by the company project sponsor and director, involving other company staff, the Associate and academic supervisor. This combination of company and university staff, each with their complementary areas of knowledge, generally worked well, although there were some inter-personnel issues at both EBS and BP that had some negative impacts, but nothing too serious. University-company collaboration was at the core of these projects, which were based on the two entities working together for mutually beneficial ends. It required significant commitment from both organisations, which was detailed in the original project proposals and reviewed in the final reports to the funding organisations. The intensity of technology transfer was also of significance and yet varied between the three cases. It was strongest at OCS, where the company staff had little experience of major software projects and the use of appropriate

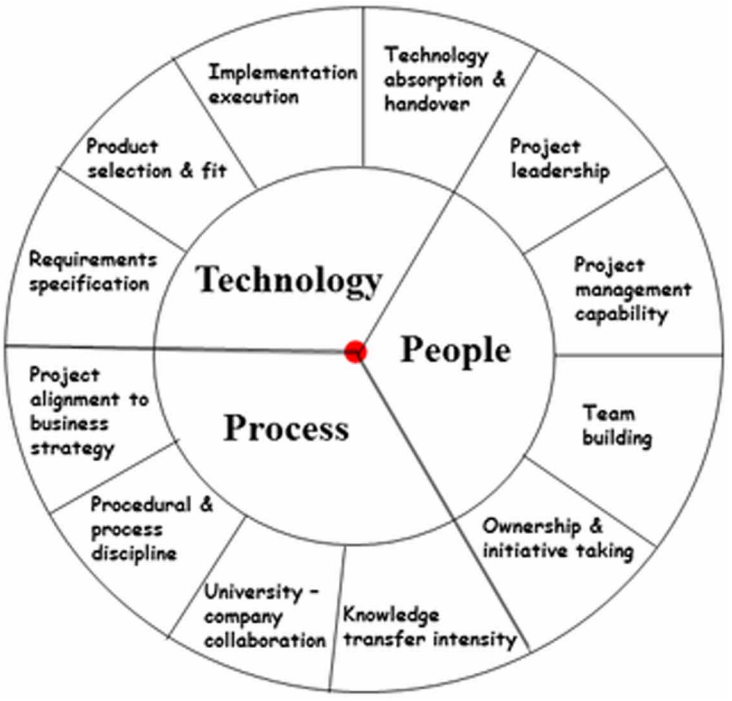
methodologies brought "a disciplined approach to the acquisition and implementation of packaged business software" (Technology Strategy Board, 2010, p.2), and at EBS, where staff had knowledge of, but little experience with using, the web based tools deployed in the project. It was less so at BP, where the laboratory manager had significant knowledge of the equipment to be installed.

Some other key process factors stand out as having been of significance. Procedural and process discipline, allied to knowledge of project management methodologies, was essential in keeping these two-year projects on time and to budget. Regular project management meetings (weekly or fortnightly) were held on the company premises, with all required actions to be minuted, communicated by email, and reviewed at the next meeting. The alignment of the technology change with overall business strategy was also evident in all three cases, and this undoubtedly underpinned project success. At OCS, the new systems were a key enabler to the successful merger of two companies and enhancement of customer service and improvement in internal administration. At EBS, the new technologies provided the opportunity for a change in product delivery and company strategy; and at BP, the in-sourcing of the laboratory function brought new revenues and was part of an upgrade in systems and processes that led to the acquisition of the company by Amerisource Bergen, a large American multi-national.

The above discussion suggests a model of twelve factors that underpinned successful technology transfer in these projects (Figure 1). These factors can be used as a model to assess the readiness of SMEs to successfully undertake technology transfer projects and to assess project progress. A detailed assessment of the three case studies shows how they varied in performance against the different factors in this model. Using a five level Likert-type scale, projects were scored individually against the 12 factors and in total. This was done through personal reflection and further review and assessment of the document sources noted above.

OCS and BP were the two highest scoring of the three case study projects, scoring 54 and 51, respectively, out of a possible 60. Despite the successful impact of the project at EBS, it scored only moderately overall – 43 out of 60 - mainly because of personnel issues reflected in poor scores for

Figure 1. The 12 factors underpinning successful technology transfer in the three case studies



most of the elements in the people category, notably team building effectiveness (Figures 2-4). This aligns with the funding body's assessment of these three projects as B, B and C respectively, but it provides detail of strengths and weaknesses in the project, which the funding body's assessment does not. Whilst the OCS project was very strong on project related skills and capabilities, and the project at BP was particularly strong on the requirements specification and product selection for the laboratory equipment, (reflecting the experience and knowledge of both the Associate and the company line manager), EBS suffered from weaknesses in the process and people elements. It is a testament to the technical ability and perseverance of the company management and staff that the project was finally successful in product innovation.

Was Technology Transfer More Successful in Innovating Internal Processes, Improving Service Provision, or Developing New Products?

This question can be addressed through an overview of the fourteen projects in the initial review (including the three case studies). Of these projects, the majority introduced new technologies to improve internal processes (Table 1), with some of these projects achieving significant process re-engineering and organisational change. For example, at Pegasus Retirement Homes the implementation of a new CRM system represented a step change in Pegasus' ability to analyse marketing and sales data and hence increase sales. An investment of £250,000 was made in a Virtual Private Network (VPN) and wireless technology, allowing sales staff to work remotely from different Pegasus offices and access the CRM system. As a result Pegasus required fewer administrative staff to support an expanding sales team, saving £150,000 per year. The project dramatically increased the rate of sale through enhanced CRM capability and improved communication to staff and customers.

Similarly, at C&G Services, a new web-based course booking and administration system (Course Booker), which went live in late 2007, provided faster information processing and better access to

Figure 2. Change factors in the optimum consultancy services project

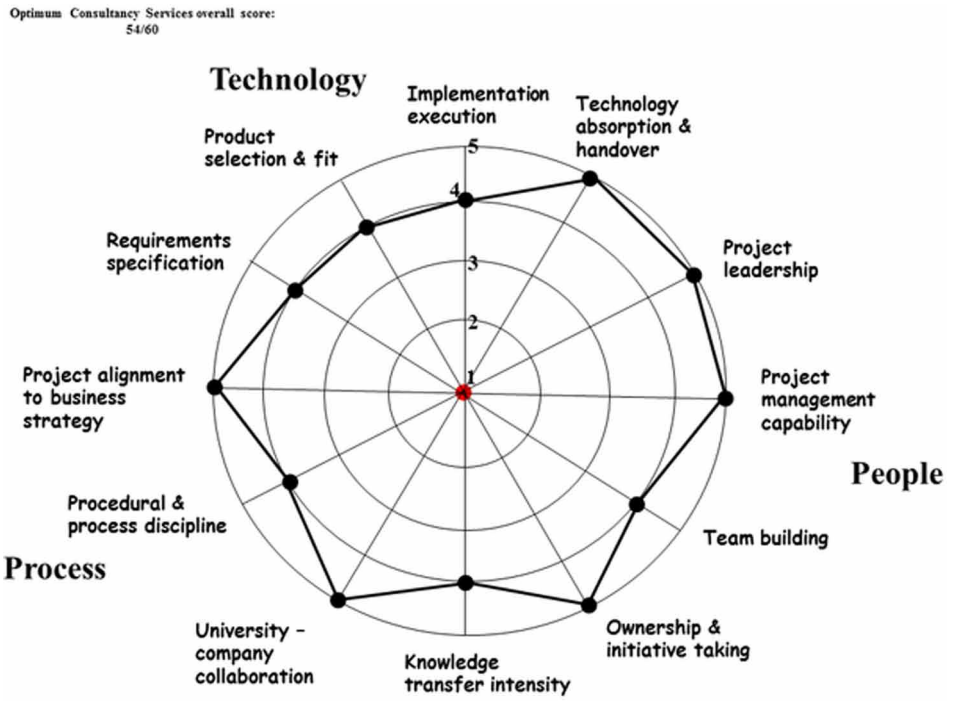


Figure 3. Change factors in the Brecon Pharmaceuticals project

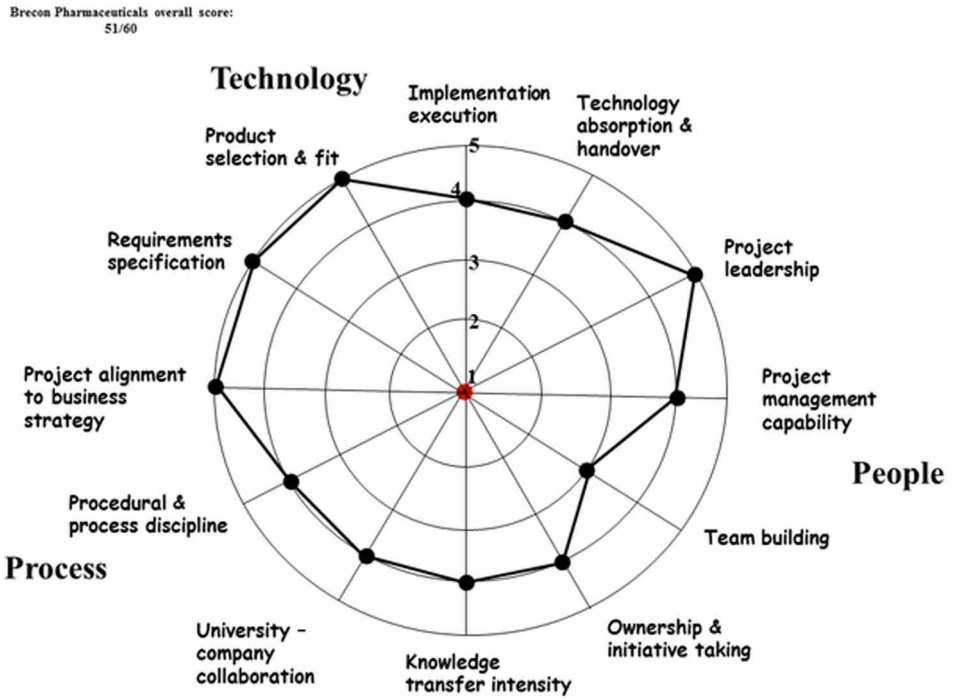
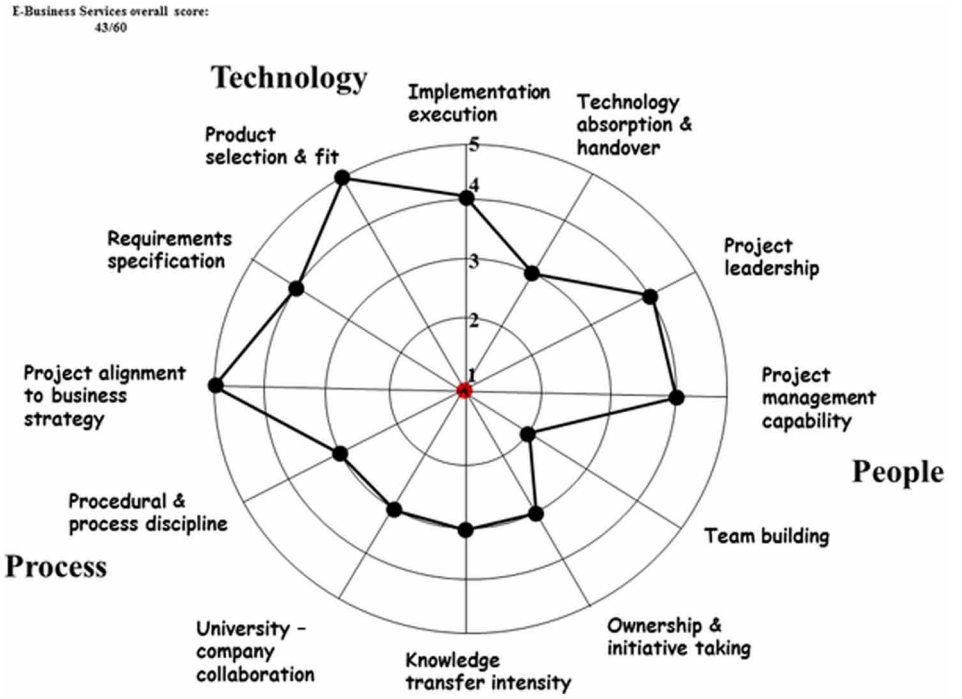


Figure 4. Change factors in the E-Business Services project



key data for both clients and staff, allowing more time for proactive work with current clients and prospective clients. Clients' access to training course schedules and the associated booking procedures was significantly changed. Greater information visibility allowed staff more control over workload, seen by clients in terms of improved and more proactive support facilities. These two companies, along with OCS, are the best examples of processes being radically changed, if not totally transformed, by the transfer of knowledge allied to new technology.

Other than BP, one of only two other projects that attempted service innovation via the introduction of new technology was at TPG DisableAids, a provider of equipment for the elderly and disabled, which employed 47 staff at the commencement of the KTP project in 2009. The company assembles and distributes a wide range of products from primary manufacturers, such as Stannah, who make a range of stair lift products. The KTP project designed, developed and implemented a range of bespoke middleware and data warehouse products to connect its existing legacy systems to a web-front end, providing the systems capability to respond to the equipment and service requirements of the NHS and related bodies at short notice, as the elderly and disabled leave hospital and return to their homes. The NHS e-procurement initiatives required specific inter-organisational systems integration which the company had hitherto not had, and the project provided this capability, facilitating a significant change to the service offered to major customers. In effect, this project made it possible for the company to change both the process and the service for procurement of its products by the NHS and others.

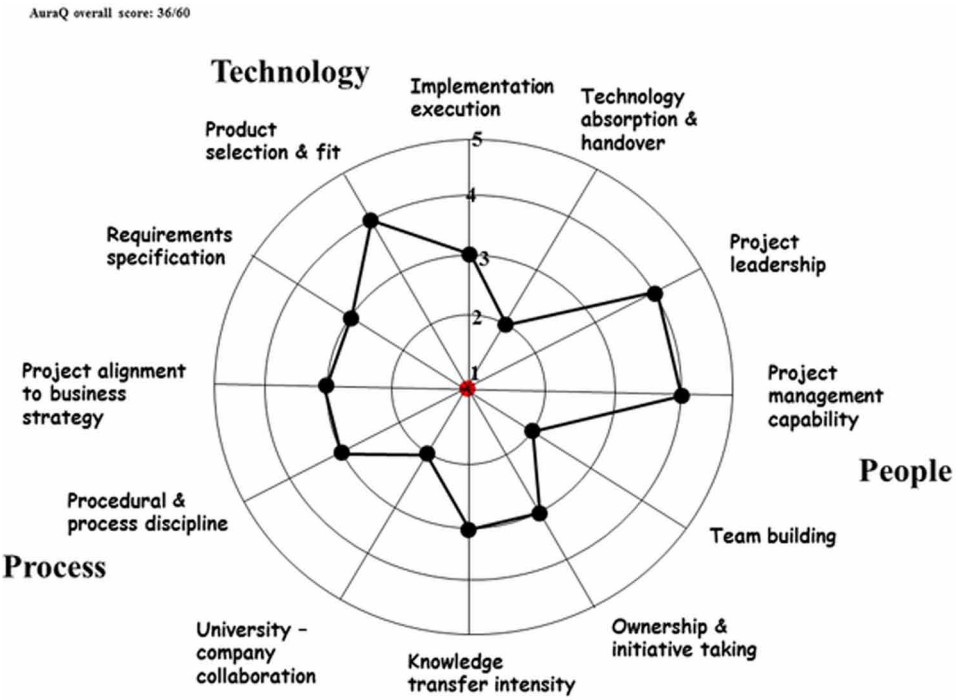
Three of the fourteen KTP projects had the objective of product innovation through technology change, and this proved the most difficult to achieve. At Matchriver, a small software house in Cheltenham, the initial aim of the KTP project was to design, develop and bring to market a software system for the tracking, management and margin analysis of industrial services projects. Unfortunately, Matchriver's intended business partner in this venture (DBI - a waste management company) altered their company strategy so this project never materialised. In early 2006, the Associate was re-assigned to work on the integration of various systems within an existing Matchriver development project - CACHE (Council for Awards Children's Care and Education). This was a technically challenging project, and did contribute in a small way to a new software solution, but the original intention of product innovation had been replaced by a maintenance and integration initiative.

The project at AuraQ (Figure 5) also aimed at product innovation but failed to deliver against targeted objectives for different reasons. The project commenced in 2010, at which time the company had been trading for ten years (albeit under a previous name for most of this period). The company specialised in business process improvement services, and had built its turnover steadily over this period to achieve revenues of over £0.5m in 2009. The company's business plan at that time entailed a move towards software solutions rather than services, and specifically to provide bespoke software components based on the Metastorm Business Process Management (BPM) product range.

The project researched and developed these new BPM tools to support a new revenue stream aimed at doubling turnover within a 3-year period. The design and development of new templates for Metastorm's business process modelling software would also embed new skills to re-position the company as a leading niche player in the business process management solutions field. However, shortly after completion of the project, Metastorm were bought out by OpenText who halted the development of the Metastorm product. Although AuraQ still support Metastorm users, the envisaged expansion based on the new Metastorm templates did not materialise. Nevertheless, by forging links with new business partners, the company came through some turbulent financial times in 2010-11, and now have 33 staff compared with just 6 when the KTP was started; but the product innovation prototype developed in conjunction with the university was never brought to market.

Overall, evidence from these projects suggests that technology transfer for process change or service improvement is likely to be most successful. Technology transfer to effect product innovation, on the other hand, proved far more problematic, and, of the three companies that attempted this, only the project at EBS could be judged as a success against original objectives, and even this is qualified by personnel issues that dogged the final year of the project.

Figure 5. Change factors in the AuraQ project

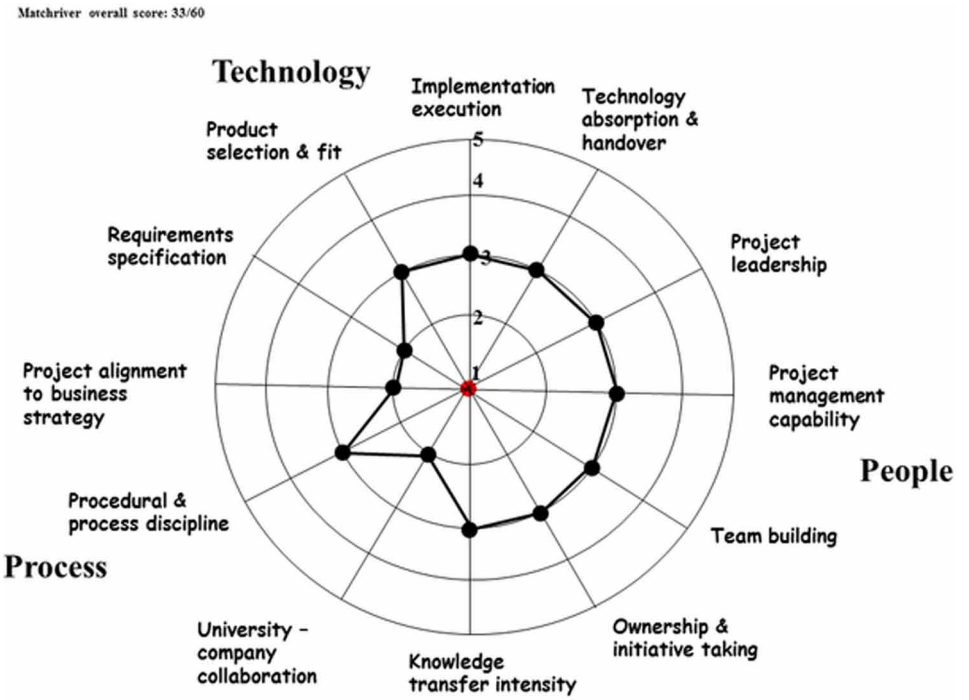


This is borne out by the funding body assessments of these projects (Table 1). The average rating of the eight process focused projects was between B and C, and that of the three service improvements projects was similar; but the three product development projects averaged a rating of D. The model developed in this analysis allows a more detailed understanding of what happened in these projects. For example, the product development projects at AuraQ and Matchriver (Figure 6) have been assessed against the model discussed above. As in the three case studies, the key documents have been reviewed and considered alongside personal reflection. The assessment against the model shows scores of 36 and 33 out of 60, very much in line with the funding body assessment of these two projects, which were graded D and E respectively. The model, however, provides some insight into where things went wrong. At AuraQ, despite some strengths in terms of project leadership and project management capability, the project was undermined by a weakness in university-company collaboration and team building. In such a small firm, this was a major flaw, and the Associate was in effect working on a project that would never come to fruition. At Matchriver, there was a similar failing in university-company collaboration, notably at the academic supervisor level, which led to a poor requirements specification and subsequent drift into a failed project.

CONCLUSION

The related concepts of technology transfer and open innovation have been discussed in recent literature (Hagedoorn & Ridder, 2012; Mention & Asikainen, 2012; Striukova & Rayna, 2015), but much of the empirical evidence available to date has focussed on high technology industries, and this has often been in large multinational companies (Vanhaverbeke, Vermeersch, & De Zutter, 2012). The model discussed in this article makes a contribution to theory and practice in the field of technology transfer for SMEs that are not advanced technology users. Brunswicker and Vanhaverbeke (2015,

Figure 6. Change factors in the Matchriver project



p.2) identified the dearth of knowledge regarding "internal capabilities for managing innovation" and concluded that "little is known about the role of such integrative managerial practices for innovation in external knowledge sourcing in SMEs".

As regards future research, the developed model will be applied to other knowledge transfer projects, both academically and operationally. Moshonsky, Serenko and Bontis (2014, p.71) noted that "academic knowledge is only relevant to industry if it motivates practitioners to take action inspired by its content" and that "future research examining the transfer of academic knowledge to practice should focus on knowledge transfer mechanisms". In this context, the model put forward in this article provides a framework for periodic monitoring and review of technology transfer projects. An assessment of progress and competence relating to the twelve change factors provides a comprehensive overview of project status which can help maintain the desired balance between the different dimensions of multi-faceted projects such as those discussed here. The model builds on existing literature and is currently being applied and developed in the analysis of other technology transfer projects.

In the projects studied here, the focus and impact of technology transfer varied. The majority of projects (eight of the fourteen in the initial review) focussed on introducing new technology to achieve process improvement, with three projects attempting product innovation and three providing service improvement for external customers. The impact of these projects can also be contrasted, achieving significant success for process and service improvement projects, but unsatisfactory results - with the exception of EBS - in product development projects. Those attempting to develop new products through technology transfer face a number of challenges that process and service innovation usually do not – particularly changes in the external environment that affect market potential of new products and the reassessment of risk factors that may lead to delays or reduction in internal project support. In such circumstances, university-company collaboration, perhaps above all other factors, is likely to be key to a successful outcome.

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