University-Industry Technology Transfer in the UK:

Emerging Research and Opportunities

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Foreword

All but ignored in the time of Adam Smith, the central role of technology and innovation to successful business growth is widely acknowledged today. Building on its expertise in basic science, the UK as a nation has a superb track record in developing and applying technologies in industries such as pharmaceuticals, advanced manufacturing, aerospace and automobiles.

In these and other areas the role of the UK university sector has been especially marked. The UK rightly has a global reputation in higher education, and over recent decades universities have proven increasingly adept at working with small and medium sized (SME) companies, often as part of complex integrated supply chains.

But elsewhere, the picture is more mixed. UK manufacturing productivity lags behind its principle European competitors, and much of this can be traced to a long tail of less innovative SMEs. SMEs as a whole play a key role in the UK economy, as employers and as producers, but as many studies have shown the sector has a long way to go to meet the best international standards in management, human capital development and adoption of new technology.

Given all this, the publication of this book by Martin Wynn, a well-known academic/business expert practitioner, is especially welcome. It focuses in detail on the use of Knowledge Transfer Partnerships in companies across nineteen detailed case studies, reviewing the experience of those involved in each case, defining outcomes and analysing strengths and weaknesses, both at the individual level and overall.

By adopting a regional focus based on Gloucestershire and Herefordshire, the author has been able to assess a cross-section of real-world cases that act both as a snapshot of one specific area and as a wider reference point for SMEs in general.

The book covers a wide range of mainstream technologies from customer relationship management, enterprise resource planning and e-procurement

systems, to bespoke developments for e-business operations and new product development. It can be read with great interest by business professionals and practitioners involved in technology transfer projects.

Jesse Norman
MP, UK

Jesse Norman *has been the Member of Parliament for Hereford and South Herefordshire since 2010. Educated at Oxford University (BA) and University College London (MPhil, PhD) he was a Director at Barclays before entering politics, and combines wide business and academic experience.*

Preface

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 is often seen as a catalyst for achieving increased competitiveness, particularly for small to medium sized enterprises (SMEs). SMEs are defined in a European context as having less than 250 staff (European Commission, 2016), including small business enterprises (SBEs) which have between 10 and 49 staff. 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 (Guzzini & Iacobucci, 2017).

Brychan (1999) underlined 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). This is particularly relevant in the UK where there are 5.4 million SMEs, providing over 60% of all private sector employment, with a combined turnover of £1.8 trillion. According to Close Brothers (2011) "over half of SMEs in the UK have invested in new technology and software, and one in four plan to do so in the future" (p.11). In addition, they found that SMEs are "most positive about technology's ability to improve staff efficiency (50%) and help upskill staff (43%)" (p.11).

For all sizes of organisation, the external environment for technology is rapidly evolving. This necessitates regular upgrades to information systems

and technical infrastructure and adjustments to future information technology strategies, and technology transfer involving support from third parties is one way of achieving this. However, as Bozeman (2000) concludes, this is not a straightforward process. He notes 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" (p.627).

This book examines the introduction of new technologies into companies partnering with the University of Gloucestershire within the framework of the UK's Knowledge Transfer Partnership (KTP) scheme (discussed below in the Introduction section). 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 from third party technology vendors. The term "technology transfer project" is thus used with the qualification that the transfer is more about knowledge, know-how and expertise relating to technology, rather than the technology itself.

UNIVERSITIES AND KNOWLEDGE TRANSFER

The concept of knowledge transfer is not new (Decter, 2009), but there is now a major interest in its role in promoting economic growth and job creation. Hardhill and Baines (2009) concluded that "the promotion of knowledge transfer to maximise public investment has been a recurrent theme in UK policy documents" (p.82) and the university sector has played a significant role in knowledge transfer to industry in the UK for several decades. Lee et al. (2010) found that universities were a valuable source of knowledge and innovation for start-up companies, but also for established businesses where

knowledge transfer can play a crucial role in their organisational development. In addition, knowledge transfer and innovation often have spill-over effects that can create wider benefits to the overall economy. The KTP scheme is of national significance in the UK in providing a financial and management framework for effecting such change, with government funding being made available to support companies that wish to take advantage of the wide range of expertise located within universities.

In a European context, the KTP scheme is a useful model, as it is generally agreed that similar mechanisms have not, as yet, been as well embedded in university-industry linkages as in the UK. The European Union's Commissioner of Enterprise and Industry has noted that "European universities and other public research organisations need to engage more actively in the exploitation of publicly-funded research results. It is necessary in order to stimulate innovation and maximise the benefits of publicly funded research, so we can turn scientific research into new products and services, which will create new industries and jobs" (EurActiv, 2008, p.2). There are, nevertheless, voluntary guidelines in place for European universities and industry to engage in knowledge transfer (Commission of the European Communities, 2007), but it is in the UK in particular that collaborative relationships between universities and businesses have received growing attention from governments and academics.

A number of government commissioned reports and reviews have explored ways of extending and enhancing these relationships and have made a wide range of recommendations designed to further that end. The Lambert Review of Business-University Collaboration (Lambert, 2003) acknowledged the scale of public investment in 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" (p.31). The Sainsbury Review (Department for Innovation, Universities and Skills, 2007) concluded that "while our knowledge partnerships seem to be working well for our research universities, there is scope to increase knowledge transfer from business-facing universities to small and medium sized enterprises" (p.60). It was in the same year that Chesbrough discussed and defined the open innovation concept that the Department of Trade and Industry specified a range of products for promoting and enabling knowledge transfer and innovation, in particular to support technology transfer to SMEs (Department of Trade and Industry, 2003). Now, in 2018, the UK Government is preparing to establish a "knowledge exchange framework" for universities and collaborating companies. One of the supporting research documents in this initiative (Higher Education Funding Council for England,

2016) reports that "evidence points to the UK university system operating at world class standard in technology transfer practice" (p.4).

The organisational and broader economic and social benefits of academic engagement with the business world have also been explored within academic literature in the UK and in many other parts of the world (Ankrah et al., 2013; de Wit-de Vries et al., 2018; Perkmann et al., 2013; Puerta Sierra & Jasso Villazul, 2018). A variety of collaborative relationships have been studied, but nevertheless, Wang and Lu (2007) concluded that there was "a lack of in-depth study on the process of knowledge transfer between university and industry, in particular how knowledge is transferred across institutional boundaries between university and industry during the interactive process" (p.120). It is this interface that this book addresses, particularly in the context of SMEs, who "often miss several important activities associated with the technology transfer that are critical for the quick deployment and success of the new technologies being transferred" (Jagoda, Maheshwari, & Lonseth, 2010, p. 366).

TECHNOLOGY TRANSFER AND INNOVATION

Technology transfer will normally involve innovation to some degree and this has been a recurrent theme in government support for small firms. Twenty years ago, Hoffman, et al. (1998) noted "of particular interest is the way in which SMEs innovate, and much recent policy-making has been directed at mechanisms to support this activity" (p.40). They found that there were many individual countries operating SME support schemes – for example, the Business Links programme in the UK which provided access to innovation and technology counsellors to help SMEs with innovation related problems. These support networks were the forerunners of today's KTP scheme and more recently, the Sainsbury Review (Department for Innovation, Universities and Skills, 2007) identified the need "to make the most of publicly funded research and to increase innovation in business and public services" (p.60). In 2013, the Technology Strategy Board, one of the main funding bodies for the KTP scheme, stressed the importance of innovation in securing KTP funding (Technology Strategy Board, 2013); and in a different national context, Silva, Gaia, Caten and Facó (2017) found that "cooperation between industry-university can increase in a significant way the capability of enterprises' innovation" (p.49).

However, there are different definitions and varying degrees of innovation. 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 projects discussed in this book. Urabe (1988) defines innovation as "the generation of a new idea and its implementation into a new product, process or service" (p.3). Similarly, Popadiuk and Choo (2006) suggest that "innovation consists of new ideas that have been transformed or implemented as products, processes or services, generating value for the firm" (p.308).

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) suggest that "so far, little is known about the role of such integrative managerial practices for innovation in external knowledge sourcing in SMEs" (p.1242), and Enkel, Bell and Hogenkamp (2011) have noted that "we still lack a clear understanding of these mechanisms….. and how we can gain maximum advantage from this approach" (p.1162). 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" (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), "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" (p.1243). 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 as a key factor in determining successful outcomes.

KNOWLEDGE MANAGEMENT

There is a clear link in the literature between knowledge management, innovation and technology transfer. For example, Gloet and Samson (2016) researched the relationship between knowledge management and innovation 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" (p.55). 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" (p.1).

This is reinforced by Wu, Hsu and Yeh (2007) who note that "although the importance of knowledge transfer has been recognized for years, the determinants of knowledge transfer still remain unclear" (p.335). In their study of sales teams in the e-travel industry, they identified two important determinants of knowledge transfer - knowledge sharing and learning intensity. They concluded that "overall, the results support the argument that social capital facilitates the determinants of knowledge transfer" and that "this finding is robust at the team level" (p.335). Similarly, Silva et al. (2013), in their study of technology transfer and knowledge management in a Brazilian technological innovation centre, found that "innovation and knowledge management processes in a company can be understood as a cluster of commitments generated by individuals aiming to create, acquire, transform, apply and subsequently protect the creation of knowledge generated by the organization in order to remain competitive in an active market" (p.80). They concluded, however, that "there is no single model for creating and managing organizational knowledge in all organizations that seek technology transfer, as each organization has its characteristics and a different culture from one another" (p.86).

Rafiei, Akhavan and Hayati (2016) researched the role of knowledge management in successful technology transfer in the Iranian aerospace

industry in an attempt to identify the key factors and variables affecting the assimilation of technology. Their findings indicated "that there is a significant and positive relationship between knowledge management and successful technology transfer effectiveness" and that "relational and organizational capabilities - as key factors and facilitators - play a mediating role between knowledge management and technology transfer" (p.178). In the same vein, Nahar, Al-Obaidi and Huda (2001), in looking at knowledge management in international technology transfer, found 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" (p.356).

PURPOSE AND ORGANISATION OF THE BOOK

This book examines how technology transfer has operated in university-company projects undertaken in SMEs via the KTP scheme. It adopts a qualitative case study approach, focusing on 19 different cases drawn from companies in the regions adjoining the University of Gloucestershire, UK. A model of twelve change factors that underpin successful outcomes is used to assess and compare these projects. The projects examine how new technologies were introduced to promote innovation in internal processes, in services to customers, or in new product development. This builds on existing theory and models in the field of study, and highlights the significance of these change factors for the effective delivery of technology transfer projects in SMEs.

The related concepts of technology transfer, innovation and knowledge management have been discussed in recent literature (Mention & Asikainen, 2012; Striukova & Rayna, 2015), but much of the empirical evidence available to date has focussed on high technology industries, often in large multinational companies (Vanhaverbeke, Vermeersch, & De Zutter, 2012). The model discussed in this book makes a contribution to theory and practice in the field of technology transfer for SMEs that are not necessarily advanced technology users. Brunswicker and Vanhaverbeke (2015) 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" (p.1242).

Moshonsky, Serenko and Bontis (2014) 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" (p.71). The model put forward in this book 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. It can be used as 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.

A recent report by the Confederation of British Industry (CBI) concluded that British businesses are falling behind their European competitors by failing to adopt established technologies, a trend which is undermining productivity and harming growth and living standards. The report noted that there is "low-hanging fruit" worth as much as £100 billion of gross value per annum, and that companies needed to invest in well-established systems to catch up with more advanced countries. The report (Confederation of British Industry, 2017) found that "failure to adopt tried-and-tested technologies and management best practices" was a "a major driver" (p.10) of low productivity, and Carolyn Fairbairn (as cited in Wallace, 2017, para.5), the CBI's director-general, concluded that "the UK is a decade behind Denmark - the proportion of companies with e-purchasing, enterprise resource planning [systems] is below the level where Denmark was in 2009."

This book examines how technology transfer projects such as those cited by the CBI have been accomplished in a range of industry sectors. It does not attempt to make generalisations about these sectors, but rather provides examples from these sectors. Nor is this book about the commercialisation of technology developed in universities by third parties. It is about how companies, and particularly SMEs, can successfully implement proven technologies to support their growth and development.

The book is organized into seven chapters. The first six chapters look at case examples of technology transfer projects in different industry sectors, and each chapter uses the change factors assessment model discussed below in the Introduction section.

Chapter 1 concerns the *contract packaging industry* and examines three projects that had varying degrees of success in promoting company growth.

Chapter 2 focuses on two companies in the *construction sector*, both house builders, but operating in different sub-sectors. Although the business models underpinning these companies' operations were very different, both

succeeded in implementing a range of new systems to support process change and bottom-line growth.

Chapter 3 examines four projects in the *software development industry*, three of which concerned new product development. The cases illustrate the problems faced by small software companies when introducing new technology products into a dynamic and competitive marketplace.

Chapter 4 looks at four projects in the *service industries sector*, comprising environmental, training, project management and financial transaction services companies. New customer relationship management systems were introduced in three of the four companies in an attempt to improve customer facing processes.

Chapter 5 reviews three projects in two companies from the *product assembly, sales and marketing* sector. One company is in the office furniture and design business, where improved management information from its legacy systems was viewed as critical for company growth. The second company, who sell a range of products for the elderly and disabled, adopted a new information systems strategy and then implemented bespoke e-procurement systems. The projects exhibit varying degrees of success.

Chapter 6 looks at three manufacturing companies. Two of these companies looked to implement integrated enterprise resource planning systems to support process change and improved management information, whilst the third company adopted a "best of breed" strategy that linked shop floor data capture systems with point solutions for transaction processing and management reporting.

Chapter 7 concludes with a review and analysis of all nineteen projects included in the book and discusses the relevance of this research for current and the future technology challenges.

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Martin Wynn
University of Gloucestershire, UK

Introduction

OVERVIEW

In 2003, the Department of Trade and Industry (DTI) specified a range of products for supporting and promoting innovation, particularly in the field of technology development and application (Department of Trade and Industry, 2003). One of these products was the Knowledge Transfer Partnership (KTP) scheme, which has provided direct support of circa £25m per annum for graduates and their supervisors to undertake specific knowledge transfer projects in firms of all sizes, but particularly in small to medium sized enterprises (SMEs). It was the successor to the Teaching Company Scheme (TCS) that had been in operation since the 1980s (Lipscomb & McEwan, 2001).

The focus of this book is on *technology* transfer in SMEs via the KTP scheme, and this section provides an introduction to some of the key elements explored in the book. As Hannabuss (2001) pointed out, knowledge provides a justification and motivation to alter decisions, and industry practitioners require knowledge to develop and carry out their technology implementation plans. Simmons et al. (2001) established that the process of knowledge transfer mostly fails on the side of the receiver, and Serenko, Bontis and Hull (2011) have argued that future research should focus on knowledge transfer mechanisms and how to improve the overall process.

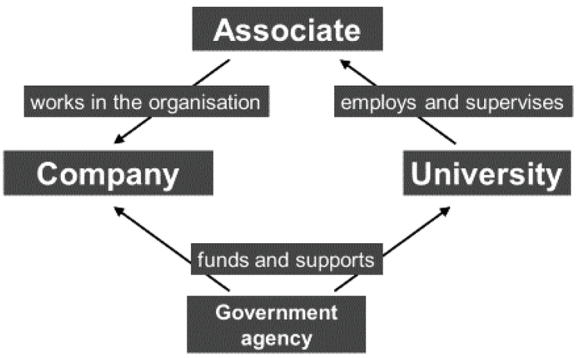
This book attempts to do precisely that, and in the following sub-section, more information regarding the KTP scheme is provided, along with an overview of the nineteen projects reviewed in the book. This is followed by a review of the research methodology and a discussion of the analytical models used in assessing the projects that feature in the book. Most of these projects were completed some years ago, now allowing a considered assessment of what was of significance in determining their outcome. Indeed, because of the context and impact of some of these projects, it was judged appropriate to wait until now before attempting such a review and analysis.

KNOWLEDGE TRANSFER PARTNERSHIPS

KTP projects are a four-way partnership (Figure 1) between the university, the company, the graduate (or "Associate" as they are termed), and the UK Government sponsoring agency, who provide up to 67% of the required funding. The scheme aims to help businesses to innovate and grow by linking them with a university and a graduate to work on a specific project that will meet a core strategic need with the focus being on delivering increased profits for the business partner. Innovation is a key focus of these projects, which may involve a number of different themes, but the projects studied here concern technology transfer in one form or another. The university recruits and employs a suitably qualified graduate - the Associate - who then works at, and brings new skills and knowledge to, the business. The partnerships involve the Associate working in an organization 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 £70K per annum, of which the SME contributes circa £23K per annum.

There are also many benefits for the partner universities, both to the institution and to the individuals involved in the projects (Wynn & Turner, 2013; Wynn & Jones, 2017); but the focus in this book is mainly on the impact these projects can make in terms of technology in the partner

Figure 1. The four-way partnership that underpins KTP projects



companies. Innovate UK (formerly the Technology Strategy Board, and prior to that, Momenta and the Teaching Company Directorate), now the main UK Government agency responsible for this scheme, 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 (Technology Strategy Board, 2013); 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 (A being excellent; E being unsatisfactory).

Since 2003, the University of Gloucestershire has completed 45 KTP projects and in 2013/2014 their Gross Value Added was estimated at £4.1m (Biggar Economics, 2015). Of these 45 projects, 30 were with SMEs, and 30 were related to technology transfer, with the focus being on, for example,

Table 1. Company projects featured in the book

Company Name	Core Activity	Project Duration	Headcount	T/O (£m)
Allpay.net	Financial technology services	2007-9	190	21.8
AuraQ	Process management software & services	2009-11	5	0.5
Beacons Business Interiors	Office design	2004-6	47	6.9
Beaumont Travel	Bus operator/software developer	2005-7	35	0.9
Brecon Pharmaceuticals (1)	Pharmaceutical packaging	2003-5	162	5.6
Brecon Pharmaceuticals (2)	Pharmaceutical packaging	2004-6	231	7.6
Building Solutions	House builder	2005-7	75	5.8
C&G Services	Training services	2005-7	25	1.2
Contrapak	Contract packaging	2009-11	52	1.2
Dowty Propellers	Aircraft blade manufacturer	2004-6	181	N/A
E-Business Services	Web based software developer	2006-8	6	0.2
Energist UK	Environmental consultancy	2009-10	40	1.1
Fixing Point	Roofing materials manufacture	2006-8	53	5.4
Muddy Boots	Supply chain software	2010-12	30	1.3
Optimum Consultancy	Project management services	2008-10	35	2.4
Pegasus Retirement Homes	House builder	2003-5	39	10.4
SKF AeroEngine Bearings	Bearings manufacture	2007-9	250	17
TPG DisableAids (1)	Equipment for elderly & disabled	2005-7	35	2.8
TPG DisableAids (2)	Equipment for elderly & disabled	2009-11	47	4.3

the introduction of new information systems, new e-business technologies, or software product development. This book examines nineteen of these projects in which the author was involved (Table 1). Only at one company – E-Business Services – are aliases used, for reasons of their customer confidentiality agreements. Both the company name and the customer names cited in this case are aliases.

RESEARCH METHODOLOGY

The research underpinning the material presented in this book is based on the well-established qualitative case study approach. Such case studies may be used to develop theory as a result of data analysis (Saunders, Lewis, & Thornhill, 2009). A case study approach allows a "detailed investigation of one or more organizations, or groups within organizations, with a view to providing an analysis of the context and processes involved in the phenomenon under study" (Hartley, 1994, p.323). Case studies "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. Silverman (2013) noted that case studies provide a complex and rich understanding of change projects across a period of time, thus allowing for an appreciation of causality and history, set in a local context. Yin (2012) argued that selection of multiple cases should consider a similar context so that a set of multiple facts can 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 the research upon which this book is based can be characterized as interpretivist, based on an inductive approach.

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. The main documentary sources were as follows: the original project proposals which were written in conjunction with the company managers, and contained project plans and detailed task lists as well as a clear cost-benefit case for the project; the minutes of the weekly project review meetings and of the three monthly Project Board meetings held with the

local representative of the UK Government's funding body; the project Final Reports, of which there were two for each project – one jointly authored by the company and the university, and the other written by the Associate (in the following chapters, " Final Report" assumes authoring by the university and company unless otherwise stated as by the Associate); the numerous reports and documents produced by the Associates across the course of these projects (e.g. Quality Plans, Project Briefs); and the many emails sent and received across the duration of these projects and in the time since project closure. 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. These findings were supported by more recent phone conversations with project team members and company management. This allowed further assessment of the projects overall, the decision making involved, and knowledge input processes of team members. Walsham (1995) notes that "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" (p.76).

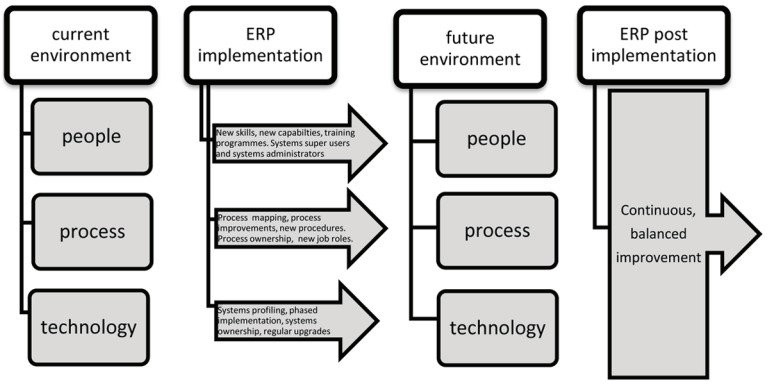
Framework analysis (Mason, Mirza, & Webb, 2018) was used to identify the key change factors in these projects. Since it was originally developed by Ritchie and Spencer (1994) for the management of data in applied policy research, this technique has been deployed for qualitative analysis in a number of areas, including research into the psychological (Parkinson et al., 2016), health (Gale et al., 2013) and sociological (Neale, 2012) fields. A series of key steps are followed leading to "highly structured outputs of summarised data" (Gale et al., 2013, p.2). The central output is a matrix table of rows (representing the cases) and columns (of different coded themes or topics). Each cell in the matrix contains summarised data, organised by case and code. This allows for large datasets to be readily viewed and compared, by reading across cases and comparing cases by code.

MODEL DEVELOPMENT

A number of models have been used to assess technology change projects such as those discussed in this book. The stages of growth model (Nolan, 1979), the e-business adoption ladder (Taylor & Murphy, 2003), the Connect-Publish-Interact-Transform model (Department of Trade and Industry, 2004), and the organizational capabilities model (Willcocks & Sauer, 2000; Levy & Powell, 2003) have all been used in various research initiatives to assess such projects. However, these models focus in the main on depicting *what* happened rather than explaining *why* or *how* it happened. Nevertheless, other studies have attempted to identify the key determinants of successful technology transfer. For example, as already noted, Wu, Hsu and Yeh (2007) pointed out the importance of knowledge sharing and learning intensity, and Knockaert et al. (2011) highlight the significance of top management composition in determining project outcomes. The research findings presented in this book attempt to identify 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) of Essman and Du Preez (2009), and its subsequent development by Enkel, Bell and Hogenkamp (2011), who identified the 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). The analysis of projects in this book builds upon 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, and to ensure projects are kept in balance as implementation proceeds. Three main dimensions of change - relating to people, processes and technology aspects of a project - are used as the overarching framework for assessing these twelve factors. These dimensions of change have been used in the analysis of systems projects (Figure 2), and have also been depicted as the three pillars of success in technology change projects by a number of authors (Department of Trade and Industry, 2004; King-Turner, 2014; Wynn et al., 2016).

As noted above, framework analysis (Mason, Mirza, & Webb, 2018) was used to identify the range and salience of key items and concepts, and

Figure 2. The three change dimensions of people, process and technology in ERP systems projects
Source: Wynn and Rezaeian (2015, p. 87)



to discover relationships between them. In inductively analyzing the main documentary sources and personal observation notes, a two dimensional framework was constructed comprising the three dimensions of change (people, process and technology) on one axis, and the nineteen projects on the other axis. Building upon an initial pilot research study of three projects (Wynn, 2018), the sources were searched for data relevant to any particular cell in this framework. This produced a matrix of thematic content assigned to the three areas of operation. The data was processed from the matrix format into a mind map for each project, which enabled a further clustering of themes and related issues. This structurally coded data was then synthesised into twelve main change factors that were of relevance to all projects (Figure 3). These are:

Technology Dimension

1. **Requirements Specification**
    a. **Functional Specification:** Was there a clear statement of what the technology should do from a user/functional perspective?
    b. **Technical Specification:** Was there a clear statement of the technical aspects that the new technology must adhere to (database, programming language, operating system, technology strategy)?
    c. **Sign-Off Process:** Was a clear sign-off process for computer users and technical support staff in place and adhered to?
2. **Product Selection and Fit**

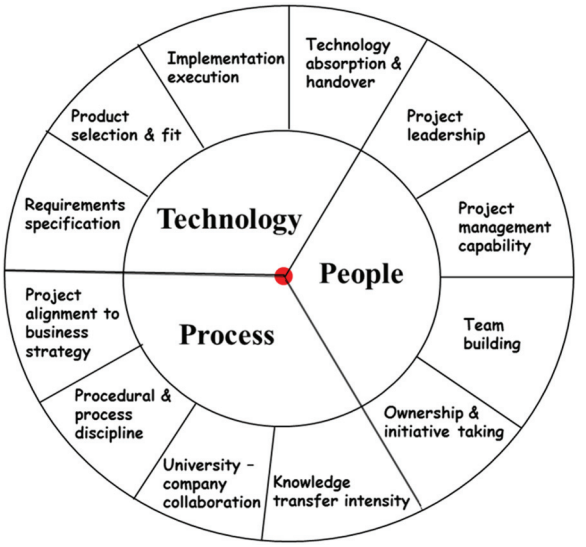
a. **Packaged Software:** How well did the system meet the needs of the company? Did it have the required functionality? Was customization necessary? Was it user-friendly? Was it generally accepted by the end-user community?
b. **Development Tools:** If software was developed as part of the project, how appropriate were the tools used?
c. **Other Technologies:** If other technologies were introduced, were they a good fit to requirements?
d. **Technology Performance:** Were there any performance issues in terms of response times, overheads on processors or networks?

3. **Implementation Execution**
   a. **Project Planning:** What was the project planning process? What did the project plan look like and how effective was it in guiding the implementation process?
   b. **Resourcing:** Were adequate human and financial resources allocated to project implementation? Were computer users made available for systems testing and training?
   c. **Product Delivery:** Were the main products delivered on time and to specification?
   d. **Contingencies:** Were contingencies needed to complete implementation and were they made available?
4. **Technology Absorption and Handover**
   a. **Technical Documentation:** Were new products adequately documented, with appropriate walkthroughs of material with the company technical support staff?
   b. **User Manuals:** Were user manuals made available, used in training and formally handed over?
   c. **End-User Champions:** Were key users identified to take on on-going maintenance and support.

Process Dimension

1. **Project Alignment to Business Strategy**
   a. **Clarity and Communication:** Was the company's business strategy clearly documented and communicated?
   b. **Project Alignment:** Was the project clearly aligned to the business strategy? Was the business strategy referenced in the project submission documentation?

Figure 3. The 12 change factors underpinning successful technology transfer



c. **Strategy Evolution:** Were project priorities reviewed in the light of changes in business strategy?

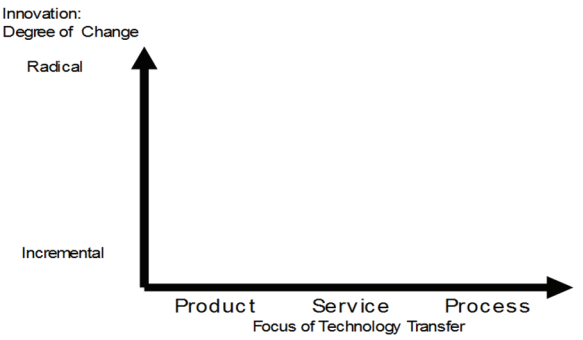
2. **Procedural and Process Discipline**
   a. **Adherence to Agreed Meeting Format:** Did weekly project review meetings take place? Did the quarterly Project Board meetings take place? Were these meetings adequately attended? Were they minuted and were members held to account regarding agreed actions?
   b. **Evidence of Project Management Deliverables:** Were appropriate project management reports, briefs, quality plans etc. developed, signed off and made available for consultation and review?
   c. **Documentation Control:** Were all key documents efficiently stored, version controlled and made available to appropriate personnel.
3. **University-Company Collaboration**
   a. **Academic Supervisor/Lead Roles:** Did the academic supervisor/lead contribute to the formulation of the project proposal? What role did he/she play in implementation?
   b. **Wider Collaborative Actions:** What other university-company activities paralleled or followed on from the project (e.g. follow-on KTPs, university delivered training)?
4. **Knowledge Transfer Intensity**

a. **Audit:** By project end, what were the main categories of knowledge transferred in terms of technical knowledge and skills, project management capability, process change concepts etc.? What was the depth and significance of this knowledge regarding the project?
b. **Post-Project Review:** Did the company retain the skills and knowledge adequately to continue support and progression of new technologies implemented in the project?

People Dimension

1. **Project Leadership**
   a. **Role of Company Project Sponsor:** Did the project sponsor play an effective role in managing the project and resolving issues within the company (e.g. of resourcing, inter-personnel problems, project planning issues). Was there an escalation process in place to get issues recognized and resolved at the senior management level?
   b. **Role of Academic Team (Associate and Supervisor):** Did the Associate play a significant role in project leadership within the company? Was he/she viewed as the project manager by in-house staff? Did he/she lead effectively, in terms of communication and relationship building? Did the academic supervisor play an effective support and facilitating role, and generally contribute to problem resolution?
2. **Project Management Capability**
   a. **Project Management Knowledge and Training:** To what extent was project management knowledge in evidence? In particular, had the Associate project management experience? Was project management training undertaken prior to, or during, the project for key members of the project team?
   b. **Use of Project Management Methodology:** Was a formal project management methodology used to manage the project? If not, what less formal methods were deployed?
   c. **Documentation:** What project management documents were generated and stored as part of the project? Were they signed off by appropriate staff? Were they made readily accessible? Were they seen as key documents and used effectively in the project?
3. **Team Building**
   a. **Team Formation:** Was a project team formally established to run the project under the direction of a team leader? What was the

Figure 4. Two-dimensional model for assessing focus of technology transfer and degree of innovation



composition of the team – did it contain appropriate personnel from the university and the company departments affected by the project?

b. **Team Operation:** How did the team operate? Were there formal regular meetings? Did it rely on informal communication? Were actions agreed and minuted?

c. **Team Performance:** Was the project team effective in carrying out the key project planning and implementation tasks? Did the team have the combination of skills, knowledge and competencies to perform effectively? Did the team work well together?

4. **Ownership and Initiative Taking**

a. **Company Project Ownership:** Was the project well sponsored and supported by senior management in the company? Was there a clear route for issue escalation and resolution when problems arose?

b. **Associate and Supervisor Ownership:** Were the university staff fully engaged in project delivery? Did they align adequately with company culture and values?

c. **Initiative Impact:** Was there evidence of new initiatives to promote the technology transfer and project delivery processes? Did the Associate demonstrate the knowledge, capability and confidence to make an impact with new ideas and initiatives? Was this in evidence from the academic supervisor or other project team members?

The resultant model will help fill the gap in the existing literature identified by Filippetti and Savona (2017) when referring to university-industry 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" (p.720), but nevertheless "the analyses of factors that slow down or hamper cooperation have been rather overlooked" (p.724). The technology transfer projects examined in this book are from a range of industry sectors, and, prior to project commencement, the companies' use of technology was generally at a low to medium level, as defined by Alvarez and Iske (2015). As noted above in the Preface, several authors (Urabe, 1988; Popadiuk & Choo, 2006) have seen innovation as being applied to either a product, process or service, and Puerta Sierra and Jasso Villazul (2018) extend this to technology transfer, considering it to be "a voluntary and active process of disseminating or acquiring new experiences or knowledge, with the purpose of improving products, services and productive processes of enterprises" (p.2). This concept is adopted in the assessment of the technology transfer projects studied here, with each project focusing, in the main, on either process change, service improvement or product development. Similarly, the distinction between radical and incremental innovation (Pedersen & Dalum, 2004) discussed above is also incorporated into a two-dimensional model which is used for comparison of projects in each industry sector (Figure 4).

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