# THE ROLE OF JAPANESE CORPORATE R&D IN THE UK:

# MEASURING BUSINESS AND ACADEMIC BENEFITS

A Dissertation

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# ABSTRACT

A growing number of Japanese companies based in the UK are keen to capitalise on science-based innovation through collaboration with local higher education institutes (HEIs). There are very few studies on the research and development (R&D) strategies of Japanese companies, particularly ones that have focused on open innovation strategies in the UK. This study attempts to clarify how Japanese companies absorb capacities through advanced R&D with local universities and identifies the benefits and spill-overs that affect UK academics.

Previous studies have shown the limited level of internationalization of R&D led by Japanese companies abroad. Japanese multinational companies are characterized by a vertically integrated R&D system, in which decision-making is largely carried out at the head-quarters in the company's home country. Compared to US and European companies, it is argued that Japanese companies cannot fully utilize local human resources and capabilities to build horizontal links among subsidiaries of their global R&D networks.

Traditionally, multinational companies tend to utilize accumulated competitive

advantages in home countries and based upon them, they exploited overseas market and expanded global business. Nowadays, however, it is unlikely to perceive competitive advantages of one nation state and domestic innovation cluster can be sustained for a foreseeable future.

A sophisticated framework of management of innovation is necessary to find out how Japanese companies based in UK can get the most value out of research collaboration with local UK science communities. In this study, questionnaires and interviews of senior managers of Japanese companies in the UK were carried out to investigate the different levels of satisfaction in companies situated in different kinds of geographical areas: in science parks, on campuses and at independent sites. The results reflect the patterns of interactions led by those companies and, more importantly, show the way in which such companies absorb capacities through learning processes in local academic networks.

A range of institutional arrangements to promote university-industry collaboration have been employed in the UK. Science parks are deemed as important players in accelerating knowledge transfer and technology-intensive companies operating in science parks are expected to contribute to the high growth of employment and licensing, as well as having spill-over effects through inter-firm networking. This study investigates to what extent Japanese companies respond to such expectations and how Japanese corporate R&D has been embedded in local innovation networks, utilising the advantages of excellent research environments by locating their R&D centres geographically close to the higher education institutes.

An equally important aim of this study was to clarify the impact of foreign-owned R&D collaboration on the local science community. It has been argued that universities play a significant role in national systems of innovation so increased attention has been paid to their commercial outputs through technology transfer to measure the success of academic-industry collaboration. A primary mission of universities now is to develop economic benefits; this is largely measured by the number of patents, licenses and spin-offs produced and the diffusion of entrepreneurial universities.

In contrast, emerging debate on the entrepreneurial nature of universities has raised questions about the motivation of academic scientists to engage with industry. Given the fact that large companies tend to monopolise most of the assets, global companies moving into the UK would deprive university academics of some of their freedom in choosing academic research and publication topics. As such, this study focused on interviewing local academics involved with Japanese corporate R&D to find out what they value most about collaborating with Japanese companies, how UK university researchers sustain academic freedom, and investigate underlying incentives and motivations behind sustainable collaboration.

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## CONTENTS

**List of Abbreviations**

| | |
|---|---|
| HEIs | Higher Education Institutes |
| UKTI | UK Trade and Investment |
| HEFCE | Higher Education Funding Council |
| PCA | Principle Component Analysis |
| MNEs | Multinational Enterprises |
| BIS | Department of Business, Innovation and Skills |
| RC | Research Councils |
| KTN | Knowledge Transfer Network |
| MRCT | Medical Research Council Technology |
| LEPs | Local Enterprise Partnerships |
| UKSPA | UK Science Park Association |
| AIST | Advanced National Institute for Industrial Science and Technology |
| NIMS | National Institute for Materials Science |
| MLIT | Ministry of and, Infrastructure, Transport, and Tourism |
| NISTEP | National Institute of Science and Technology Policy |
| IPO | Initial Public Offering |
| EPSRC | Engineering and Physical Sciences Research Council |
| DIUS | Department for Innovation, Universities and Skills |
| BERR | Business, Enterprise and Regulatory Reform |
| RCs | Research Councils |
| RDA | Regional Development Agency |
| SWRDA | South West Regional Development Agency |
| METI | Ministry of Economy, Trade and Industry |
| JARI | Japan Automobile Research Institute |
| TIA | Tsukuba Innovation Arena |
| TLO | Technology License Office |

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## CHAPTER ONE

# 1. Introduction

## *1.1 Background*

As a result of global competition, an increasing number of research-intensive Japanese companies have established research and development (R&D) centres abroad in an attempt to access excellent scientific resources. Before the term “open-innovation” became a buzz word, it was well-understood that academic research creates basic scientific knowledge upon which global multinational companies can build their applied R&D activities.

Japan is widely perceived as a frontrunner in advanced technology, a reputation which largely relies on their intensive in-house R&D featuring large amounts of research investment. However, faced with the continuous economic recessions of recent years, large Japanese companies engaged in knowledge-intensive R&D have become increasingly keen to identify the best academic research partners and, depending on their specific needs, go abroad to set up collaborative international R&D centres.

British R&D is characterised as being highly internationalised compared to other developed countries. A considerable share of R&D expenditure relies on foreign investment, with expenditure on UK R&D by foreign-owned companies exceeding that of domestically owned companies. The UK university sector is recognised for its excellence and so is able to attract investment from international companies and their subsidiaries to support research. Large global companies see the UK as the best partner in advanced R&D and they highly value the excellent research environment and prestigious research institutes and universities there.

With a strong science base, the UK is one of the most popular partners for R&D collaboration, as demonstrated by the large amount of R&D investment from abroad. In 2011, the UK attracted about $7 billion in overseas-financed R&D. This is about the same as the combined figure for Canada, Finland, Japan, China and Russia. While the amount of R&D finance received from overseas has increased in all sectors over the past decade, between 2000 and 2011 the most consistent increase has been in the higher education sector (Department of Business Innovation and Skills UK (BIS) 2014).

Over the past twenty years, the number of Japanese companies launching R&D projects in the UK has steadily increased. It has been widely perceived among Japanese companies that UK universities have richer R&D networks and more experience in working with industry partners than Japanese universities. The UK has been chosen as an ideal location that provides Japanese companies with easy access to the EU market, as well as an open and friendly regulatory environment enabling foreigners to pursue patent rights in a relatively efficient way. Nowadays, inward investment from Japanese companies is widely perceived to be a catalyst for creating new jobs and economic growth, and promoting knowledge-based innovation (UK Trade and Investment (UKTI) 2014).

More specifically, the majority of inward investment from Japan is shared by global companies, particularly in the following sectors: consumer electronics, information communication, and the automotive, chemical and pharmaceutical industries. UK Trade and Investment estimates that 153 R&D and design centres are owned by Japanese companies and the majority of them have headquarters in Europe (UKTI 2010). It is estimated that about one-fifth of these companies has conducted technology-intensive R&D, exploring research linkages with UK universities and research institutes (UKTI 2010).

The breadth of policies that have been employed to facilitate university-industry collaboration is exemplified by the implementation of the Lambert Agreement in the UK. A number of reviews have demonstrated the social and economic impacts of university-business collaboration (Wilson 2012). Over the last decade, UK Higher Education Institutes (HEIs) have demonstrated a sound record of commercialising basic research outcomes and have continuously attracted industrial partners from outside the country. Those identified as leading universities in terms of university-industry collaboration have established distinct institutional arrangements in order to retain the best knowledge acquired from collaborative research with global companies.

Science-based innovation and economic growth requires good collaboration between universities and businesses and this linkage in UK been underpinned by a rise in the number of science parks. The majority of top UK universities have science parks on their campuses that offer integrated spaces, attracting highly-skilled technical staff and leading researchers, both from within and outside the universities.

### *1.2 Research Purposes*

- **New Insights on Strategic R&D Management for Japanese Companies**

It is recognised that multinational companies seek to internationalise their R&D with the intention of advancing R&D capacities and encouraging localisation in terms of new products and ideas. Many studies on the internationalisation of R&D led by multinational companies have focused on their business strategies and how their management relies on analytical tools including microeconomics, business administration and organisational study (Kuemmerle 1999; Pearce and Papanastassiou 1999). They attempt to investigate the status of internationalisation, breaking it down into patterns, determining factors and influencing factors (Asakawa 2001; Kumar 2001; Odagiri 2003; Teece 2003).

It has been widely argued that the level of internationalisation of Japanese corporate R&D has so far remained modest compared to companies in the US and Europe (Bartlett & Ghoshal 1989; Gassman & Zadtwitz 1998; OECD 2007). The local subsidiaries have limited autonomy of decision-making in allocating financial and local human resources, largely due to their vertically integrated system that is strongly controlled from the headquarters in the company's home country (Lam 2003).

Especially in early stage of their investment, multinational companies from Japan tended to utilize accumulated competitive advantages in home countries and based upon this, they would exploit overseas markets and expand globally. Companies structured according to translational management systems, specifically, must follow the directions determined by headquarters in their home countries. Anymore, however, businesses are unlikely to reply on the competitive advantages of one nation state or to believe domestic innovation clusters can be sustained indefinitely. Doz et al who coined the term of metanational management succinctly demonstrate that traditional global strategies are no longer sufficient means of differentiating between leading competitors, determining what the knowledge economy means for managers or understanding why opportunities to leverage globally dispersed knowledge are growing. （Doz, Asakawa, Jose and Williamson, 1997）

More recent studies aimed to clarify the determinative factors used by globalised Japanese companies to conduct knowledge management through exploring collaboration with universities abroad. The final decision as to which location and university each company should work with is critical for the course of their future technological and business development (McGuckin et al. 2005; Thursby and Thursby 2006; Abramovsky et al. 2007; Shimazutani and Toda 2008; Suzuki, Belderbos, Hyeog and Fukao 2012). While the expansion of internationally collaborative R&D led by globalised Japanese companies and top-tier UK universities continues, we have only a limited understanding of how those companies identify the best partners and utilise scientific resources and knowledge. Given that the global R&D network has been extensively involved with local scientific communities in advanced countries, a more sophisticated framework of management of innovation is necessary to establish how Japanese companies actually get the most value out of research collaboration with local UK science communities and absorb capacities through the extensive multilevel networks.

Relying upon insights from previous literature, this study has been carried out to elucidate how Japanese companies based in the UK have made critical decisions about human resources, built partnerships with local academics and shared information to gain scientific resources and knowledge. The key questions this study sets out to answer are intended to investigate how R&D centres owned by Japanese companies utilize the advantages of local institutional arrangements to fit with their R&D strategies and create synergy within academia-industry and interactive learning. By responding to such questions, this research aims at providing a rich understanding of the open innovation system of global firms involved in collaborative R&D with local research bases in the

UK.

- **Examining the Role Science Parks Play in Maintaining Collaboration with Global Companies**

UK science parks are increasingly becoming perceived as catalysts for innovation as they facilitate dynamic interactions between various actors involved in high-technology and commercialisation activities (Higher Education Funding Council (HEFCE) 2014). Indeed, several large research-intensive Japanese companies in the consumer electronics, automobiles and pharmaceuticals industries have established their R&D laboratories in science parks managed by prestigious UK universities such as Cambridge and Oxford. In terms of new challenges and emerging issues for future science parks, both the UK and Japan share the same agenda: developing diversity and openness by promoting international scientific collaboration and commercialisation through university-industry cooperation.

The primary aims of science parks are to bring about new investment, create innovative products, support smart small and medium enterprises (SMEs) and identify new research objectives. One study examined the impact of university science parks on research productivity in the UK. By using econometric procedures, Siegel et al. (2003)

demonstrated that firms located in university science parks exhibit higher research productivity than observationally equivalent companies located elsewhere. Moreover, it has been emphasised that firms in university science parks are active and successful in terms of new products, services and patents. Empirical studies on the relative performance of companies in science parks have demonstrated that a clustering of new technology-based firms brings in additional benefits such as inter-firm networking, links with universities and research institutions, and technological spill-over within the park. (Leung and Wu 1995; Pfirmann 1995; Poon 1998)

The above-mentioned previous studies provide us with insightful indications that, as tenants in science parks, global companies are expected to contribute to the high growth of employment, inter-firm networking and research productivity. This leads us to ask, to what extent does this apply to Japanese companies? This study attempts to see whether Japanese companies have been capable of embedding themselves in local innovation networks and utilising the associated advantages of locating their R&D centres in science parks.

- **The Impact of Collaborative R&D led by Japanese Subsidiaries on UK University Research and Management**

As we witness a rise in university-business collaboration, the debate on the entrepreneurial university has raised questions about what motivates academic scientists to engage with industry. More specifically, the increased momentum towards university-business collaboration in the UK and Japan over the last decade has gradually caused growing concerns about excessive expectations being placed on enterprising universities at the expense of the conventional role of universities as centres of learning.

With the increased awareness of technology transfer accelerating the return of research outcomes funded by public investment in society and economic growth, university researchers are increasingly expected to conduct applied research into areas of high commercial value, which do not always coincide with scientifically important areas of knowledge. This study will examine the impact of UK-Japan collaborative R&D on scientific research outcomes and related educational activities, for example, the extent to which academics retain freedom in terms of their research interests and the significance of curiosity-driven research.

Since the institutional reform of Japanese universities, large domestic companies have been keen to launch exploratory research by providing access to a broader knowledge base and attracting academic partners with different areas of expertise that make it possible to carry out more interdisciplinary research (Lee 2011). However, in addition to such positive impacts, the negative effects are that inter-organisational collaboration easily encourages partnering companies to seek exclusive patent rights with the aim of profiting from technological innovations and knowledge stemming from universities. The patent right arrangements allow large firms to pre-empt inventions derived from universities by implementing exclusive use of patents by large firms (Kneller and Shudo 2008).

Large companies compete to recruit star scientists in universities in order to gain advantages over their competitors. Under such circumstances, it has been argued that this limits potential opportunities for other businesses, notably SMEs, by monopolising all the assets. It also triggers concerns that giant companies could deprive university academics of some freedom in choosing academic research and publication topics. Given these issues, several intriguing questions present themselves: how do UK university researchers sustain academic freedom when launching collaborative research with Japanese companies moving to the UK? What are the research and educational returns and benefits that local academics most value about research collaboration with Japanese companies? Are there any differences between working with UK and Japanese companies in terms of returns and benefits?

### *1.3 Policy Implication*

One of the most significant contributions of this study is that it delineates companies' organisational mechanisms and strategic processes pertinent to R&D internationalism in the UK. The findings from this study will therefore assist managers in global Japanese companies engaged in technology-intensive R&D who are keen to internationalise their R&D strategies to access an excellent knowledge base. Those experts directly involved with human resources and organisational management will value the outcomes of this research as good models for future decision-making and in the process of improving returns over cost and enhancing the capabilities of skilled workers.

The study highlights the need for further institutional arrangements to attract foreign companies as well as efforts to capitalise on foreign-hosted firms. The successful case studies that highlight the internationalisation of UK universities while retaining top research qualifications are good showcases for various key Japanese stakeholders, including the central government, regional development agencies and universities' international offices, all of whom seek to create the excellent science bases that are essential for future growth underpinned by a knowledge-based economy.

The study is intended to clarify factors quantitatively and qualitatively in order to make a robust bilateral science-based linkage and affect the course of future collaborations as it attempts to clarify the open innovation system of global Japanese firms involved in collaborative R&D links with UK higher education institutes. Such an approach provides some insights in terms of the evolving role of universities and overseas R&D labs in economic growth in parent and host countries. The following paragraphs will delineate more details about the research methodology.

### *1.4 Methodology*

Through employing quantitative and qualitative analyses, the study aims to clarify the depth and breadth of the internationalisation of R&D activities. It is important to determine the range of technological readiness shown by existing and emerging bilateral R&D, including basic research led by Japanese companies, local universities and the scientific community. Quantitative analysis of questionnaires can yield a large volume of data and provide an overview of trends in the internationalisation of R&D.

As preparation for this study, the author met 21 business representatives affiliated with 13 top Japanese companies in order to gain knowledge of their R&D management processes and technology investment priorities. The key questions were focused on the following three issues: 1) the degree of their interest in UK research capabilities; 2) the most prioritised areas of R&D; and 3) decision-making and external factors influencing R&D management followed by further information about the company's R&D operation (The list of interviewees can be found in Appendix 3 in the end of Chapter 6).

In May 2012, the author conducted a survey by distributing questionnaires to 153 Japanese companies located in the UK with support from the British Embassy Tokyo and Japanese Chambers of Commerce. Following this, 23 companies were identified as the most proactive in terms of collaborative R&D with local UK universities. Those companies were classified by different locations in order of geographical closeness to partnering HEIs: *1) on campus, 2) in science parks* and *3) at independent sites.* The original survey letter and questionnaire are attached in Appendices 1 and 2 respectively. Then the statistical analysis of the non-parametric analysis, specifically the Mann-Whitney test and Principle Components Analysis (PCA) for categorical data, are applied in order to elucidate incentive factors in order to identify the academic partners and examine the positive impact of geographical closeness on R&D and commercial affairs overall.

Between 2012 and 2013, the second stage of interviews were conducted in the UK with 10 business representatives, including senior managers equivalent to the director or deputy director, of R&D centres owned by the following 6 Japanese subsidiaries in UK companies: *1) Hitachi, 2) Toshiba, 3) Sharp*, *4) Nissan*, *5) Takeda Pharma* and *6) Harada Industry.* These companies are selected as they all ranked highly in terms of R&D expenditure and have adopted smart strategies with local top researchers to maintain their growth in the UK. Each interview was particularly intended to provide an understanding of the structure and strategies in their UK R&D investment and ongoing collaboration with local experts as well as how they obtain benefits accruing from such joint R&D.

During the same period of time, 14 interviews were also conducted with the aim of uncovering the underlying incentives and research and educational benefits for local academics who continued collaborative R&D led by the Japanese companies that show a high level of satisfaction as a result of the above distributed questionnaire. The selected interviewees are experienced professors in terms of university-business collaboration (U-B collaboration) and have been involved with R&D collaboration led by Hitachi, Toshiba, Nissan and Eisai; they are affiliated to the following seven universities: *1) University of Cambridge, 2) Imperial College, 3) University of Oxford, 4) University College London, 5) Bristol University,* and *6) Durham University.*

In order to investigate the impact of specialised environments designed to promote technology and knowledge transfer through U-B collaboration on the performance of Japanese tenant companies of science parks, the author carried out 3 interviews with the CEO of the UK Science Park Association as well as senior managers in the Oxford, Bristol and Kent Science Parks.

### *1.5 Structure of the Thesis*

The thesis is composed of seven chapters. The next chapter summarises previous studies on the internationalisation of the R&D of global companies, re-examining the assumption of limited internationalisation of Japanese corporate R&D affected by vertically integrated management system. The most recent research looking into the case study of Japan and the UK delineates the various patterns of U-B collaborations and examines the impact of a range of policies implemented earlier in this decade on academic/scientific research capabilities and new business opportunities.

Chapter Three summarises the features and capabilities of UK science and technology, underpinned by advanced R&D financed by foreign affiliates, and the rise of highly qualified international co-authorship as well as the growing impact of university-business collaboration on economic growth.

Chapter Four outlines the results of the questionnaires with 153 Japanese companies based in the UK and clearly identifies the 23 most proactive companies in terms of collaborative R&D with local HEIs. Statistical analysis is employed to demonstrate the level of satisfaction in each company in three different geographical areas: 1) on campus, 2) in science parks and 3) at independent sites. The questionnaires and interviews are intended to clarify how Japanese companies absorb capacities by carrying out advanced R&D with local universities as well as to identify the benefits and spill overs that affect the UK academic sphere.

Chapter Five consists of an account of the comparative study the researcher conducted in UK and Japan science parks, namely Cambridge and Tsukuba. The study examined the Japanese companies as tenant companies of Oxford, Cambridge, and Kent Science Parks to explore the geographical advantages obtained by being a tenant company based in a science park and to assess the function of UK science parks and intermediate organisations as gatekeepers to accelerate technology transfer.

Chapter Six summarises the interviews with senior academics from UK top tier universities involved in collaborative projects with Japanese companies with the aim of clarifying the benefits local academics obtain from the research and educational perspectives as well as clarifying whether any differences exist between this type of collaboration and collaboration with domestic companies. The interviewees were distinguished professors working with Japanese companies whose responses to the distributed questionnaire (detailed in Chapter Four) indicate higher satisfaction rates.

# CHAPTER TWO

## 2. Literature Review

### 2.1 International R&D under Globalised Economy

The global economy is developing into a technology-centred form of production as "stateless" high-tech companies increasingly arise, encouraging further collaboration (Reich 1992). A considerable number of studies have highlighted the significant role of R&D activities in fuelling economic growth as they generate new knowledge and profitable technological innovation (Grossman and Helpmen 1991; Aghion and Howitt 1992).

The internationalisation of R&D is basically derived from innovative technology intensive firms. There is no doubt that the success of global companies' activities, in particular those in industrialised countries, can largely be ascribed to the internationalisation of collaboration in the area of R&D. The growing role of the internationalisation of R&D sometimes causes political concerns since the international partial externalisation of innovative activities through inter-firm partnerships inevitably triggers a tension between international partnering benefiting from foreign capabilities (Duystaers and Hagedoorn 1996). Ostry and Nelson (1995) coin the term “techno-nationalism” to delineate the coexistence of conflict and cooperation in international R&D.

The study of the internationalisation of R&D has developed over the last two decades and most early studies examine the pattern of internationalisation and its determinative factors as an influential power. Such studies can be classified into the following four categories based on chronological order: 1) Conducting an exploratory study on the internationalisation of global R&D (Florida 1997; Mowery 1998; Patel and Vega 1999); 2) investigating specific activities conducted by foreign companies (Kuemmerle 1999; Pearce and Papanastassiou 1999); 3) clarifying determinants for international R&D (Kumar 2001; Odagiri 2003); and 4) evaluating outcomes of international R&D and knowledge management (Asakawa 2001, 2003; Teece 2003).

In order to examine the determinants of R&D location decisions, McGuckin et al. (2005) carried out 42 in-depth interviews with large multinational R&D performers in four high-tech industries and found that the drivers for the location of “Research” and “Development” appear to differ. The former is more associated with academic centres of excellence and is most generally implemented in proximity to universities and alliance partners. On the other hand, development activities tend to be carried out close to the target market and to customers, manufacturing units and suppliers. The study significantly elucidates the evidence of “home country bias”, whereby research projects and teams are located in close proximity to the company’s headquarters since this offers opportunities for collaboration and cooperation.

In a similar vein, Thursby and Thursby (2006) present results from a survey of over 200 multinational companies across 15 industries regarding the factors that influence decisions on where to conduct R&D. Respondents were asked to separately rank the most important factors in the decision to locate R&D facilities outside the home country or within the home country. The interviews also distinguished between locations in developed or emerging economies.

The decision on where to locate R&D facilities is complex and influenced by a variety of factors, of which nationality of ownership is only one. Results from a recent EU survey (European Commission 2006) show that, in more than 60% of cases, firms stated their home country was one of the three most attractive locations. The underlying reasons for this preference for the home country may be geographic proximity to other company sites, familiarity with the national socioeconomic environment and, of course, language.

While companies prefer to choose an R&D location within their country, this location is then subject to the overall R&D strategy, as is any other company site outside the home-country. The relevant main factors are related to market conditions (i.e., characteristics of the goods-and-services market, the labour market and the market for R&D), high availability of researchers and access to specialised R&D knowledge and results. Furthermore, there must be factors that fall under the category of framework conditions and reflect the predictability and stability of government policy, of the R&D framework and of R&D cooperation opportunities.

Adding to the significance of selecting location, a company's ability to absorb capacity through international R&D is deemed critical element of that company's success. Cohen and Levinthal (1989) note that maximising the results of external R&D requires effort by the recipient company. They emphasise that a company needs to invest in its "absorptive capacity" if it is to realise R&D spill overs from other companies. The effects of internationalisation depend on the following: 1) the mobility of human resources; 2) the potential for major changes in location and funding of R&D facilities by UK and foreign firms; and 3) the ability of the UK economy to benefit from foreign investment in R&D (through the take up of "knowledge spill overs"). This is in turn associated with investment in complementary assets, including skills, design and management.

This claim is also supported by Griffith et al. (2003), who state that higher absorption capacity is a significant element for recipient companies to probe for the best available external knowledge; to absorb and use external know-how in the most efficient way; and to gain their appropriation of the returns from new innovations. Companies with high absorptive capacity (measured by a company's R&D spending intensity) are associated with an increased likelihood of engaging in production and technology cooperation with other actors (Liu 2012).

### 2.2 Internationalised R&D led by Japanese Companies

With a growing knowledge-based economy over the last decade, major global companies that used to have in-house R&D centres increasingly recognise the need for open innovation by outsourcing their basic scientific research. Large Japanese companies are no exception and so continuously strive to find the best academic partners abroad, thereby intensifying the internationalisation of R&D collaboration with the aim of comprehending new technologies through which to acquire knowledge spill overs.

As the increased number of Japanese companies moving into developed countries were observed in 1980s and 90s, the accumulated studies featured its distinctive home centric strategies. They observed a strong tendency for Japanese companies to retain resource and capacities and authorities in home country and critical decision making in foreign subsidiaries is solely determined by head office based in home country (Bartlett & Ghoshal 1989; Gassman & Zadtwitz 1998).

Focusing on Japanese distinguished nature of vertically integrated R&D system, it was argued that the Japanese companies in abroad cannot fully utilize the local human resource and capabilities to build a horizontal human network among subsidies (Bartlett & Ghoshal (1989). Compared to US and European MNCs, the degree of internationalisation of Japanese MNCs has been remained modest as the limited autonomy of decision-making and less empowering local employees in very vertically centralized system controlled by head office in Japan.

Some studies significantly depict their distinguished business manner. For instance, Asakawa's study distributed questionnaires to 193 research facilities (62 headquarters and 131 laboratories) owned by Japanese companies. The analytical approach adopted makes it possible to evaluate management strategies in international R&D departments, specifically the relationship between parent companies and subsidiaries and the autonomy of both parties (Asakawa 2001).

Furthermore, Asakawa succinctly demonstrates that the overseas labs seek more information sharing and more autonomy than do their parents. Such circumstances tend to cause tension and perception gaps between headquarters and overseas R&D (Asakawa 2001). Interestingly, this approach could also to re-examine the network structure, including the structure of linkages within and outside companies. The study finally evaluates capacity building (absorption capacity, conversation capacity and combining capacity) and demonstrates aspects of knowledge retention and mobility in a given network structure, specifically the level of network density and contingence.

An increased number of studies have explored the multinational enterprises' strategies towards human resources and transnational learning through the internationalisation of R&D. Lam (2003) first clarifies the differences in managing organisational learning with a comparative study between globalised US and Japanese ICT and pharmaceutical companies' laboratories based in the UK. Through interviews with senior representatives affiliated with R&D laboratories in the UK, the study shows that the nature of Japanese companies' links with local universities is characterised as being more aggressive or targeted while the nature of US companies is more like that of collegial players. On the other hand, the Japanese companies tend to maintain their integrated organisational and business systems, unlike the US companies who attempt to develop their organisational capacity by embedding themselves in local innovation networks.

While the above previous study has offered significant insights, there is limited research on overseas R&D with local universities, especially dealing with a case study of Japanese companies based in the UK. In this respect, Woolgar (2007) made a contribution by conducting an exploratory study on Japanese companies' R&D with UK universities through carrying out hearings and distributing questionnaires to the university researchers and industry representatives. According to his study, the Japanese firms are active in a number of R&D activities in the UK which can be classified into 1) research links through contract or collaborative research and 2) personnel exchange or training-type relationships.

The final decision as to which location and university each company should work with is critical for the future course of their technological and business development. One study focused on Japanese companies' R&D centres abroad to illuminate the actual pattern of Japanese subsidiaries based abroad; it examined 12,466 Japanese companies based in 15 different countries with a multi-nominal logit analysis. The results showed that those conducting basic and applied R&D abroad are concentrated in certain countries whose share of R&D over GDP is relatively high and that feature high knowledge capabilities (Shimazutani and Toda 2008).

With a similar goal to illuminate the determinative factors of Japanese companies, it has been empirically demonstrated that the research quality of local universities, as well as a good environment for industry-business collaboration in the host country, has a great influence on the final decision as to where to conduct R&D (Suzuki, Belderbos, Hyeog and Fukao 2012). By locating their R&D centres geographically close to universities, such companies attempt to gain benefits by having a skilled local labour force of scientists and engineers as well as useful information and knowledge.

Global companies engaged with knowledge-intensive R&D have become increasingly keen to identify the best research partners from academic spheres and so, depending on their needs, go abroad to construct international collaborative R&D. The literature on Metanational Management in today's global knowledge economy states that the nature of global competition has changed from competing to participate in the marketplace to competing to learn from globally fragmented knowledge (Doz, Asakawa, Santos, and Williams 1997).

Given the fact that knowledge base is rapidly decentralized on a global scale, the seed of innovation could take root in rather unusual regions and countries. As a result, if we continue to stereotype some countries and maintain a routine approach reliant on pre-exiting strengths in one place, we risk losing access to new opportunities (Doz, Asakawa, Santos, and Williams 1997). Without a doubt, of course, it is not easy at all to identify the next innovation hotspot. But breaking from Autarkic, self-reliant innovation strategy turns out to be of the utmost important for multinational companies. Then metanational management can pilot these companies towards looking for new potential seeds of innovation all over the world and obtaining and absorbing knowledge and capabilities swiftly-thus, making them extremely good at sharing within their respective divisions (Asakawa, 2003). Doz, et al point out the key factors that help managers build meta-national advantages for their own organisations are as follows:1) prospecting for and accessing untapped pockets of technology and emerging consumer trends from around the world ; 2) leveraging knowledge imprisoned in a multinational and local subsidiaries; 3) mobilizing this fragmented knowledge to generate innovations, profits, and shareholder value. (Doz, et al, 2001). The companies who have such advantages will eventually survive and become winners in the global knowledge economy.

Such companies are largely influenced by the distinguished economic and social systems in the host country. Significantly, it is suggested that further study is necessary to clarify the depth and width of Japanese overseas activities. There is a lack of study that fully elucidates how global companies fit within their long-term R&D strategies proposed by headquarters in a home county and how a host innovation system can capitalise on foreign-hosted companies. In order to fill such a gap, this study investigates how Japanese companies based in UK have made critical decision making in terms of human resource and build a partnership with local academics and information sharing to gain scientific resources and knowledge.

### 2.3 Strategic Role of Science Parks and Universities in Knowledge Exchange with Industry

One reason behind the high profile of university-business collaboration in the UK is its excellent research infrastructure and the environment of science parks located close to the universities. Science parks are well-designed for research intensive companies to access top scientists and engineers affiliated with the universities.

The distinguishing feature of the UK science parks is that the majority of them are owned or managed by leading universities. The most prestigious UK universities have successfully secured excellent researchers from other countries and it is noteworthy that about one-third of all UK universities own science parks or manage science parks with private venture companies and enhanced collaboration with industrial partners.

Those tenant companies could obtain advantages from geographical proximity to excellent science bases. Indeed, some of giant Japanese ICT, automotive and pharmaceutical companies have established R&D centres based in science parks affiliated with top UK universities.

Several empirical studies on the dimensions of the relative performance of companies in science parks demonstrate that a clustering of new technology-based firms brings in additional benefits such as inter-firm networking, linkages with universities and research institutions and technological spill overs within the park (Leung and Wu 1995; Pfirmann 1995; Poon 1998). One study finds that initiatives to promote companies in science parks appear to be more influential in terms of a high rate of job creation than policies to help in general are (Löfsten and Lindelöf 2002).

Looking into the case study of Japan's science parks, Fukugawa (2006) demonstrates that, although tenant companies are very keen to work with regional HEIs, knowledge linkage and management are not geographically limited to the neighbourhood of science parks. Specific strategies to maintain organisational function and human resources are crucial, but remain unresolved.

One chapter is designed to clarify the distinctive features and history of the UK and Japanese science parks and to discuss the key intermediary organisations (considered one of the essential factors for designing science parks in Japan) affecting the course of university-business collaboration. Significantly, the thesis investigates whether Japanese companies have been capable of embedding themselves in local innovation networks and utilising the advantages of excellent research environments by locating their R&D centres close to top-tier UK universities and science parks.

Research on the role of universities in the innovation systems of industrial economies has underlined the significant role of universities as institutional actors in national and regional systems of innovation (Nelson 1993). The strategic role of universities in stimulating innovation and economic growth has become the central theme in innovation and science policy in both the UK and Japan. Over the last decade, the promotion of university-business collaboration has been a common interest shared by the UK and Japan, both of whom employ a wide range of new institutional arrangements. Interestingly, the period 2000-2005 became a historic turning point for both countries as they moved forward to a new stage of university-business collaboration.

Looking into the case of Japan's university-business collaboration led by the University of Tokyo, one study succinctly delineates the incentives behind such collaboration and its impact on scientific research capabilities as well as the pattern of knowledge transfer under the transitional period of institutional change in Japan (Suzuki, Goto and Baba 2007). In a similar vein, Lee (2011) investigates how university-business collaboration in Japan has been transformed from interpersonal networks to inter-organisational alliances since 2004, a historic turning point when the institutional reform of Japanese universities took place.

Kneller and Shudo (2008) highlight the issue caused by pre-emption often observed in a typical pattern of university-business collaboration in Japan. Large companies remain the main actors in university-business collaboration and so enjoy more advantages in accessing innovative research resources in universities than small- and medium-sized companies do. Such companies attempt to gain advantages by acquiring and exploiting the excellent knowledge and innovative research resources in targeted universities and this can cause a slowing-down of open knowledge diffusion.

The conceptual thought of a triple helix focuses on the new primary mission of universities to develop economic and social benefits in addition to their traditional missions of teaching and research (Etzkowitz 1998). The diffusion of an entrepreneurial university would trigger perceived risks including a shift from basic research towards more applied topics and less academic freedom (Blumenthal et al. 1986; Behrens and Gray 2001) as well as lower levels of research productivity among academics (Agrawal and Henderson 2002).

In contrast to the advocates of triple helix theory, Perkmann and D'Este (2010) succinctly demonstrate that UK academics in the fields of physics and engineering who engage with industry are more motivated to further their research than to commercialise their knowledge; this is measured by examining the numbers of patents and spin-offs. They claim that the majority of academics conduct joint research, contract research and consultations strongly informed by research-related motives. This view is supported by Hughes (2012), who shows the importance of the various channels of engagement between academia and industry in scientific innovation and that the pattern is varied by the sector, size and life cycle of the business and its form of production.

An intriguing question concerns the extent to which the diversified role of UK universities could be observed in engagement with Japanese companies. Moreover, the study is intended to find main incentive mechanisms and motivations among university researchers in the UK to engage in interactions with Japanese companies as well as to explore how UK university researchers have gained research capabilities by establishing a variety of patterns of knowledge exchange through collaboration with Japanese companies.

# CHAPTER THREE

## 3. Overview of UK Science and Innovation

### 3.1 Historical background

Looking into the history of the last few decades, the UK has undergone a unique pathway by arranging institutional arrangement and providing a better environment to attract global companies and retain highly-qualified researchers from abroad. Faced with a decline in international competitiveness in the 1970s and 1980s—in particular, automobiles and semiconductors—the Thatcher administration was determined to attract foreign capital to rebuild the industry. In addition to drastic economic reforms, the university reforms during those decades greatly impacted the course of UK science-based R&D and innovation for economic prosperity. Reliance upon free market capitalism and the introduction of fair competition unified assessment for university education and upgraded the quality of education; otherwise, it would have been difficult for the UK to attain the world leading science base and human resources observed today. The UK's past efforts in university reforms provide great insights for Japanese universities who have been currently struggling to attain world top and to employ drastic reforms intended to promote internationalization by retaining high-quality researchers from abroad and activating brain circulation within and beyond the country.

Such dynamism is essential for economic and societal benefits and long-term future prosperity.

***Thatcher's legacy***

During the 1960s and 1970s, while other European countries experienced a so-called economic miracle, Britain was often described as the 'sick man of Europe'. The targets for blame included failure to invest in new plants and machinery, restrictive working practices, loss of markets and rise of competition. Indeed, productivity in the UK amounted to only 2.4% per year, which was the lowest among the other sixteen European countries (Abe, 2010).

Britain ran a manufacturing trade deficit in 1983, the first such deficit in the country's history since the Industrial Revolution. During that period, the British auto industry experienced a continued decline in its share of the domestic market. After the Conservative Party's 1983 electoral success, Prime Minister Thatcher tightened her control of policies affecting industrial investment and development. First, the existing centralization of authority was concentrated in her hands. Although her consolidation of power did not fundamentally change the existing structure of decision-making authority over industrial investment and development issues, it did ensure that the Department of Trade and Industry (DTI) would pursue policies consistent with Thatcher's overall market-oriented ideology. Unlike the Labour government, Thatcher's Conservative government viewed the principle of government support for industry unfavourable. The Conservatives believed that the industry's investment decisions should be left to the market to decide, no matter how important the industry (Morgan & Sayer, 1988).

The UK tried to achieve modernization and promote efficiency in order to catch up with other advanced countries. To foster the competitiveness of British industry, the Conservative government under Thatcher during the post-1983 period sought to expose domestic industries to the free play of market forces. Moreover, the government proactively welcomed foreign companies and their inward investments. Inward investment was seen as imperative to maintain and strengthen the operation of market forces in order to improve the country's economic performance. Such investment was expected to 'bring new technological skills and managerial expertise, thus increasing both the quality and quantity of output and employment in this country' (British Business, 1982).

The UK's relatively cheap cost of labour compared to other developed countries and its good accessibility to European markets, as well as the introduction of deregulation, were attractive to foreign investors. With rich experience in M&A, British people do not have negative perceptions when home companies are acquired by foreign owners. Faced with a relative decline in international competitiveness, in particular, manufacturing sectors, such as the IT industry. The government became keen to encourage U.S. and Japanese automakers and IT producers to invest in Britain. According to Industry Secretariat, Robert Jenkin stated, 'The Conservative government because the future competitiveness of our IT industry is a subject to which we attach the utmost importance…The government is convinced that this program will ensure for British industry secure access to the new technology and to the products and processes on which our future prosperity depends' (The Time, 1983).

***Transformation of the UK's science system by university reforms***

The UK's science system has undergone considerable reforms and changes during the past few decades as part of government reforms of public services. Education has been seen as a core for the welfare of British people and international competitiveness; thus, the need for open information, market capitalism and responsibilities with an aim to pursue high efficiency and improved quality of education has been strongly suggested. The educational reforms undertaken in the 1980s were based on the government's desire to raise access to higher education to be more in line with other Western European countries (Wilson, 1991).

The first revolutionary reform after the world war took place under the Thatcher administration and intended to transform an ailing university system into a world-leading system of higher education. The administration attempted to achieve a higher level of accountability for public funding and greater accountability for students as customers. For such an aim, the UK introduced a range of institutional arrangements throughout the 1980s. After the introduction of the Research Assessment Exercise in 1986, a new framework was released followed by the implementation of the Education Reform Act in 1988. This act introduced a national curriculum to provide academic backgrounds for more students to continue in school past sixteen years of age; it increased options for studying science and, subsequently, entering university (Gov. of U.K., 1994b). In the same year, the University Grants Committee (UCG) was replaced by the Universities Funding Council (UFC) and the Polytechnics and Colleges Council (PCFC). The PCFC and the UCG were also integrated into the Higher Education

Funding Council for England (HEFCE). Under such a range of institutional changes, the overall university entrance ratio increased from 8.7% in 1965 to 15.1% in 1988 and continued to 31.1% in 1994. The polytechnics created in the 1960s had a vocational focus, but the course offerings of the polytechnics had gradually become similar to those of universities. In 1992, most polytechnics attained university status.

During the Major administration (following Thatcher), the white paper 1993 refurbished the research council system and introduced a Foresight program that put researchers and business end-users together in a forum to pursue the links between basic research and applications. During the same period, the UK government established a new cabinet secretary to improve the handling of S&T policy and created the Office of Science and Technology (OST). This office deals with the science budgets of research councils and the block grants to the Royal Society and the Royal Academy of Engineering. The reform of science policy structure and funding was intended to build closer and more systematic partnerships among researchers, government and industry. In addition, in 1994, the OST began publishing ‘A Forward Look of Government Funded Science, Engineering and Technology’, which provided assessment of the portfolio of publicly funded research best suited to the broader S&T needs of the country.

While past reforms of education since the Thatcher administration is sometimes critically examined, it can be seen that UK universities have successfully retained their international competitiveness by retaining the highest-skilled resources and the brightest international students, and its level of internationalization is far ahead of Japan. David Willetts, former universities and science minister, paid tribute to Thatcher's 'extraordinary achievements' in setting the scene for 'the world-class higher education sector we have today'. Her reforms introduced a much higher level of accountability for public funding and greater accountability for students. Just one year after the reforms were introduced, international student numbers continued to grow, providing an invaluable, independent source of income to universities. Indeed, the UK is a popular destination for Japanese companies to conduct collaborative R&D, and it is ranked at third place just behind the US and China, but still ahead of Germany and South Korea. UK universities have enjoyed a successful record in world rankings, in particular, in terms of research quality and levels of internationalization, which is demonstrated by the Times Higher Education.

### 3.2 R&D Investment by Foreign Affiliates

Since the UK government began to attract foreign investment in the field of automobiles and IT sectors in 1970s under the Thatcher Administration, international R&D flows and collaborations have remained as increasingly important phenomena in formulating innovation systems, and the UK is well-placed to gain from an increase in international R&D activity. The internationalisation of R&D has been happening in the UK for some time and is a constantly increasing trend (Bloom and Griffith 2001). UK-based R&D is more highly internationalised than in comparable countries and this is reflected in an increased dependence on foreign funding for R&D. The UK is unique amongst the G8 countries in terms of the share of its business expenditure on R&D that is financed from abroad. Foreign firms in the UK appear to be relatively more R&D intensive than foreign firms based in other G8 countries. Existing data on foreign investment in UK-based R&D activity shows that the UK has been an important location for multinational enterprises (MNEs) and their associated knowledge investments.

The UK appears to be one of the foremost popular partners for R&D collaboration, as demonstrated by the large amount of R&D investment from abroad. Businesses, charities and other organisations invested some £3.3bn in knowledge and services from UK Higher Education Institutes (HEIs) during 2010-11 (HEFCE 2012). In 2011, the UK attracted about $7 billion of overseas-financed R&D. It is noteworthy that expenditure on R&D by foreign owned companies exceeds that of domestically-owned firms (HEFCE 2012).

Figure 1.1 shows the percentage of gross expenditure on R&D financed from abroad. At 16%, the UK had the highest percentage of funding from overseas sources out of the seven industrialised countries for which data is available. Continued efforts have been made to develop positive, open and mutually supportive relationships with a range of countries around the world, both to encourage investment in the UK and to enable UK businesses to export.

Over the past decade, the amount of R&D investment from overseas has increased in all sectors and, notably, the most consistent increase has been observed in the higher education sector. It is estimated that overseas-financed R&D in higher education has been growing in real terms at an average annual rate of nearly 9% (ONS 2013).

### 3.3 Expansion of International Co-authorship

The UK research base continues to produce a large output for its moderate size, with a sustained track record of high quality research. While UK universities share about 4%

of the world's researchers, UK researchers produce 6% world articles that attain 12% of citations (a key measure of research excellence) and 16% of the most highly cited articles (BIS 2014).[1] The UK's excellent scientific resources underpinned by leading universities continued to be essential for business growth as well as the core for the future prosperity in the UK. Figure 1.2 indicates the share of the most cited 1% of published scientific articles. The UK has surpassed Germany and Japan, and remains a frontrunner among seven developed countries.

Elsevier's report on the International Comparative Performance of the UK Research Base finds that the UK is ranked second among the large economies of the G7 and BRICS10 in terms of citations per paper, and also maintained above average rates of growth in citation levels from 2006-2010. More specifically, the UK research community accounts for 3% of the world's researchers and generate 6% of the world's academic articles, 11% of citations, and 14% of the most cited papers (Elsevier 2011). Additionally, the UK has maintained highly qualified research strengths and enjoyed a high citation rate for international co-authorship. Some new analyses (Nature 2013)

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[1] The UK has the highest cumulative proportion of science and engineering doctoral graduates among comparative countries with a similar proportion of science doctoral graduates to Germany and France and the second highest proportion of engineering students behind Finland. Total income has grown in real terms year-on-year since 2003/04, reaching £3.3 billion in 2010/11.

show that international research co-authorship now accounts for more than half of the UK's output, where it was just one paper in six in 1981. In fact, UK domestic authorship has very much flat-lined since the mid-1990s. The good news is that the UK is not unique because the same pattern is seen among our major partners in Europe and North America.

The amount of international co-authorship has been steadily increasing since 2008. The high quality of international co-authored papers is well-demonstrated by the higher citation rate than those with no co-authorship abroad. (Nature 2013). The rise of international co-authorship has been solely observed in the UK, although the majority of leading competitive countries in Europe have the same tendency (Figure 1.3).

The UK has been an active participant in this global process of enhanced international collaboration. The Royal Society's study shows that the annual rate of publication by the UK of internationally collaborative papers increased substantially from 1996-2008. The UK maintained its position as second in the world during this period by increasing its total output of collaborative papers as well as the share of its total publications that were produced in collaboration with other countries (Figure 1.4).

The growth of international scientific collaboration has been facilitated by the bottom-up exchange of scientific insight, knowledge and skills, and is led by scientists themselves. Such a phenomenon is not entirely new and this development of global networks is accelerating the focus of science from the national to the global level, and facilitating benefits from enhanced collaboration (such as improved quality, efficiency and effectiveness).

### 3.4 UK Strategies for University-Business Collaboration

After undertaking the reform of higher education and funding system throughout the 1990s, the UK Government employed several policy initiatives for endorsing business-industry interaction. Most recent restructure of science department took place in 2009 when the Department of Business Innovation and Skills (BIS) was created by the merger of the Departments for Innovation, Universities and Skills (DIUS) and Business, Enterprise and Regulatory Reform (BERR) that have the combined function of education, trade and industry.

Under the jurisdiction of BIS, two public funding and management organisations named the Higher Education Funding Council for England (HEFCE) and the Research

Councils (RCs) have created a portfolio of funding streams to enhance university and business collaboration and the further exploitation of research. UK RCs have expanded their collaborators through direct contact with 2,900 private sectors. Also, the Innovate UK administered by BIS determines the priority areas for investments in new business opportunities for the application of research and research capability. The above organisations have worked organically and eventually established a unique UK mechanism capable of strengthening U-B collaboration as well as accelerating technology transfer and economic growth.

A wide range of policy statements delineate policy recommendations and measures. *The Lambert Review* was published in 2003 and suggests some specific measures to enhance business-university interactions, including improving intellectual property (IP) negotiations. The Review delivers a number of proposals for building new networks among research-intensive businesses, and supports existing schemes for business-university collaboration such as LINK and Knowledge Transfer Partnerships (KTP).

The Government became keen to identify ways of directing a higher proportion of its support for business R&D to small- and medium-sized enterprises (SMEs). It is suggested that research collaborations might be easier to agree if model contracts could be developed on a voluntary basis to cover the ownership and exploitation of IP. Moreover, the Review makes several recommendations designed to encourage more frequent and easy communication between business people and academics.

Following on from *the Lambert Review*, *the Warry Report* in 2006, sponsored by Research Council UK (RCs), demonstrates the economic and social impact derived from specific Research Council funding measures. *The Sainsbury Review: The Race to the Top* in 2007 and *Innovation Nation* in the subsequent year underline the need for strong leadership roles for the Technology Strategy Board (now renamed as the Innovate UK) by working with RCs and complementing a reconstructed HEIF. The UK Government thereby attempts to continue its strong commitment and secure the financial support for U-B collaboration. Strong top-down initiatives for technology/knowledge transfer led by academia, industry, and government have been employed in UK.

Another powerful public organisation is the Knowledge Transfer Network (KTN).

Administered by BIS, it consists of experts with various fields of knowledge and with rich experience of working in private sectors. There are currently 15 KTNs focusing on highly competitive sectors to accommodate a range of technology or business applications. The main mission of KTN is to provide support for accelerating the knowledge transfer from universities to deal with the issue of Death Valley. Relying upon the extensive networks in industries and academia, KTN supports both private and public sectors through the role of match-maker by identifying which company and university owns specific technological advantages under various needs. One new initiative that has been launched is the creation of a network of world-leading technology and innovation centres called Catapult Centres, each focusing on specific technologies.

Good UK-based case studies can be observed from the successes achieved by the Medical Research Council Technology (MRCT). MRCT is a semi-private agency, operating as a technology transfer organisation for the MRC with responsibilities for the IP and commercialisation of research done at the MRC's units and institutes around the UK. MRCT is affiliated to the MRC as one of the seven Research Councils in the UK that provide public funds for medical research.

Their main activities include filing patents, licensing technology to companies, spin-out creation from IP developed at the MRC as well as organising contracts for collaboration with industry. One of MRCT's prominent successes is the original work on therapeutic humanised monoclonal antibodies developed by Sir Gregory Winter with the MRC research fund. MRCT helped Sir Gregory's research achievement with pharmaceutical companies that resulted in two medicines, which have had significant impact in the treatment of MS and rheumatoid arthritis.

As a result of a range of government initiatives, the UK is widely perceived as one of the leading countries in promoting U-B collaboration. In a similar vein, the Japanese Government has facilitated various institutional arrangements over the last few decades. The first attempt goes back to 1998 when the Act on Promotion of Technology Transfer from University to Private Business Operators was passed, and the following year when the Act on Special Measures for Industrial Revitalization was passed. The national universities underwent further changes with their incorporation in 2004, allowing greater freedom, and the amendment in 2006 of the Basic Act on Education.

Under such circumstances, the solid bases of both Japanese and UK universities have faced radical changes in terms of funding and increased pressure on research impact. In order to clarify the shared challenges and lessons learnt from past experience, the UK-Japan symposium, *Building International University-Business Links* was co-organised by the British Embassy Tokyo and British Council on 10-11 January 2012. It was attended by senior government officials in MEXT and METI, and UK and Japanese university professors and industrial mangers associated with companies deeply engaged with such collaborations.

In the aftermath of the workshop, the Lambert Agreement was translated into Japanese, which had a great impact on Japan's various stakeholders. Sir Richard Lambert, as a key founder of the Lambert Agreement who currently serves in a senior position in the Foreign Commonwealth Office, visited Japan in 2012 and delivered his lecture with insightful messages and his review of the last ten days after the establishment of Lambert Agreement.

The UK Government strongly recognises the need for the establishment of a Technology and Innovation Centre due to the rise of other European competitors as exemplified by the Franhofer Institute in Germany, TNO in the Netherlands as well as IMEC in Belgium. Recently, a wide range of government funding initiatives as well as the increased awareness of business and universities have dramatically transformed the culture of inquiry and innovation.

Professor Wilson delineated the huge changes in business-university collaboration both qualitatively and quantitatively in *the Wilson Review* in 2012. The Review underlines the strategic role of the universities as an integral part of the supply chain to business, emphasising the capability to support business growth and economic prosperity.[2]

In June 2012, Science Minister David Willets made an announcement related to specific policy schemes to enhance U-B collaboration, such as the improved matching programmes to strengthen the partnership between universities and financial bodies and to boost the mechanism of sandwich courses designed to provide university students with the to work as interns in the private sector. Willets stated that intensified U-B collaboration was expected to bring significant new opportunities to local areas. Sir Andrew Witty, CEO of GlaxoSmithKline and Chancellor of the University of

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2 Professor Sir Tim Wilson, "A Review of Business-University Collaboration", in February 2012.

Nottingham, was assigned to write an independent review with practical action points to take in terms of building relationships between universities and local business bodies such as Local Enterprise Partnerships (LEPs), which are the key partners in steering support for innovation at the local level, and working with universities, businesses and other partners.

### 3.5 Impacts for Economic Growth

UK Higher Education Institutes (HEIs) can be seen as one of the most prominent enterprises substantially contributing to the UK economy. The UK higher education sector employs more than 650,000 people and generates more than GBP 59 billion per annum for the economy. Nowadays, it is estimated some 7,500 staff working at higher education institutions are committed to conducting commercialisation through liaising with industries.

Data shows that the income derived by UK universities directly from IP is around GBP 70 million per annum or approximately 1.1% of research income. While the percentage is still smaller than that of the United States, which exceeds GBP 1.1 billion and reaches over 3% of research income, the UK has pursued a commercial approach by developing the most effective method for maximising the impact and benefits of academic research.

Indeed, the World Economic Forum Global Competitiveness Report ranked the UK as second in the world for university business interaction, ahead of the US. In fact, between 2003 and 2011, 40 university spin-outs were floated on the stock exchange with an initial public offering (IPO) value of £1.79 billion and 25 were acquired for over £3 billion. The revenue from research, consulting, and licensing has been almost doubled and reached around 2,100 from 2003 to 2008. The B-U collaborations are becoming more proactive, as demonstrated by the increased number of licensing and license fees.

The HE-BCI survey clearly shows the interaction between higher education and business and community. The number of spin-out companies produced within one year has been growing since 2005 and reached 226, the highest figure on record, in 2006. Following 2007, this number has been declined and remained as 191 in 2008. However, in 2008 spin-out companies from HEIs that sustained for more than 3 years has risen to 822, up from 748 in previous year.

According to the most recent study led by HEFCE, *Higher Education-Business and Community Interaction Survey 2011-2012*, universities in the UK contributed £3.4 billion to the economy in 2011-2012 through services to business, including commercialisation of new knowledge, delivery of professional training and consultancy. Moreover, it has been demonstrated that the total value of the services which UK universities provide to the economy and society increased by 4% to £3.4 billion in 2011-12, from £3.3 billion in 2010-11.

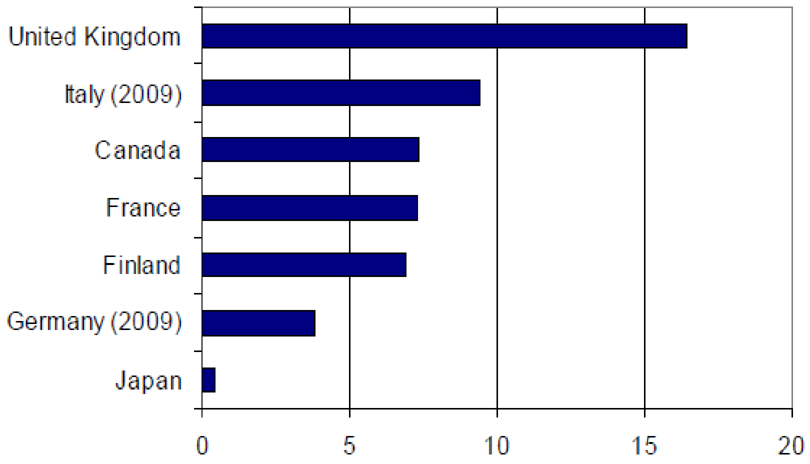
Table 1.1 shows the key indicators from the HE-BCI survey since 2003. The real-term incomes from collaborative research, contract research, and consultancy as well as intellectual property (including sale of shares) have been steadily increasing. The increase of outputs from UK HEIs measured by patent applications, patents granted, and spin-offs can also be observed (Table 1.2).

The unique feature of the UK U-B collaboration is the increased involvement of global companies that seek to access excellent research sources in UK higher education institutes for their open innovation and advanced R&D. Indeed, UK universities have been widely acknowledged for their excellence and high capabilities in attracting investment from global companies and their subsidiaries to support research. Further, top UK universities classified as world leaders in terms of basic science resources have conducted advanced collaborative R&D with foreign global companies.

Engagement with large businesses was increased by around 5% overall, including a notable rise (6%) in contract research income, from £343 million in 2010-11 to £365 million in 2011-12 (HEFCE 2013). This phenomenon not only illustrates UK higher education institutions responding to the needs of businesses at home, but also investment from overseas seeking to take advantage of the UK's world-class research (HEFCE 2013).

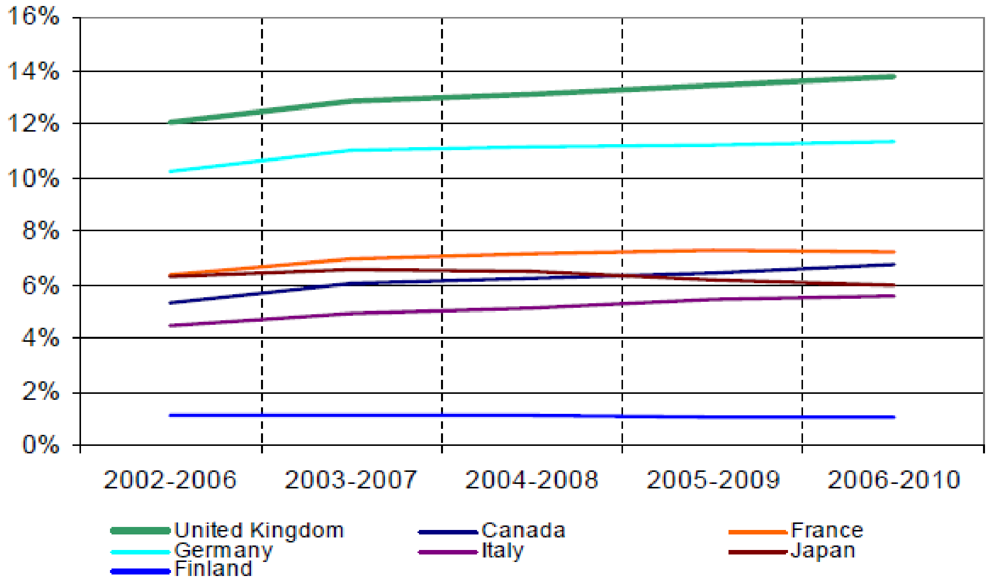
Quite a few good case studies can be observed, such as Warwick University and Tata automobiles, Sheffield University and Boeing, Kent University and Pfizer, Cambridge University and IBM and Microsoft and, lastly, Bristol University and HP. Japanese large ICT and pharmaceutical companies tend to be based geographically close to excellent research environments and so settle down near to the HEIs. About one third of Japanese companies based in the UK whose links are connected to the local HEIs are actually based on the university campus and science parks. These companies grasp mid- to long-term R&D strategies and their R&D programmes usually last over 5 years through maintaining an intensive research collaboration focused on specific partners and also through being very keen to expand to new research partners

**Figure 1.1. Percentage of gross expenditure on R&D financed from abroad, 2010.**



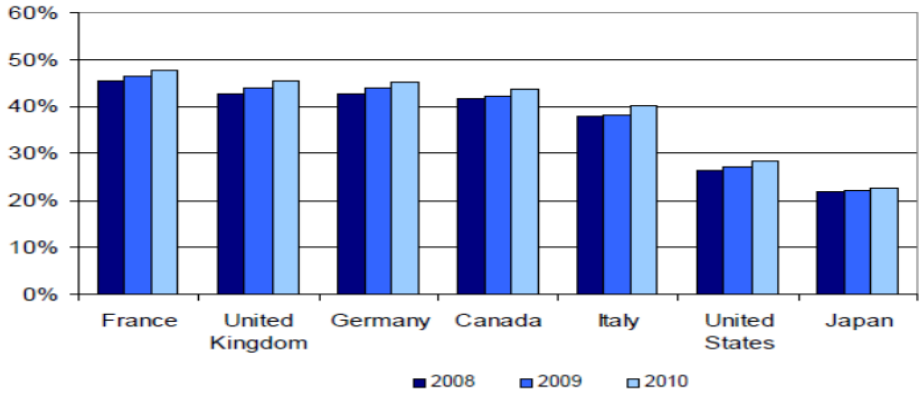

(Source: OECD MSTI, September 2012)

**Figure 1.2. Share of most cited 1% of published scientific articles**



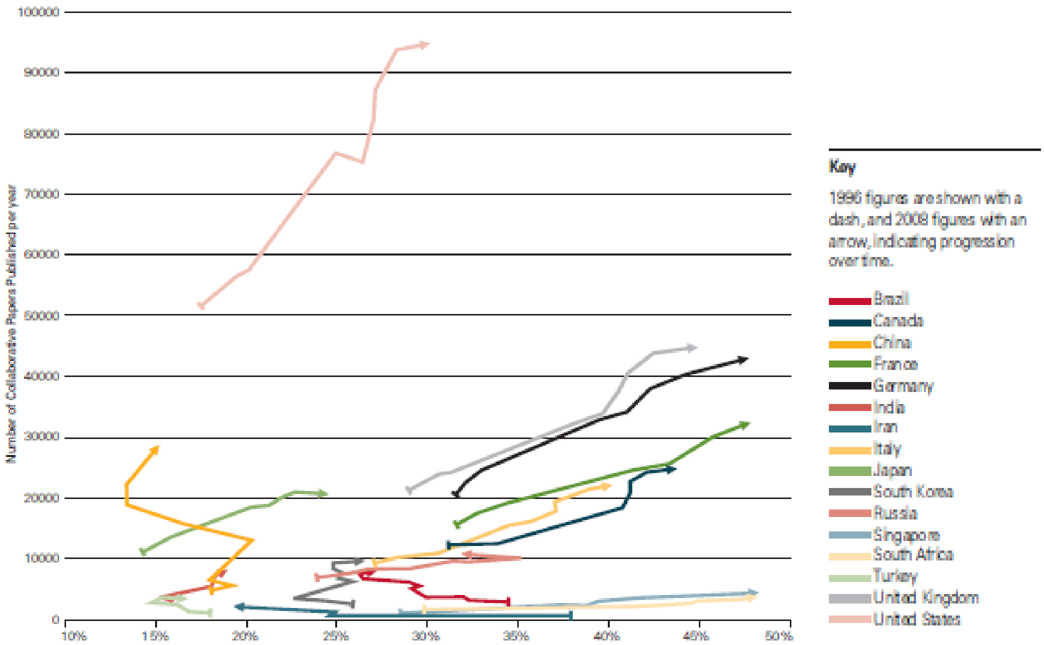

(Source: Elsevier 2011)

**Figure 1.3. Percentage of scientific articles with an international co-authorship**




(Source: Elsevier 2011)

**Figure 1.4. Growth in international collaboration for selected countries and the proportion of national output that this represents, 1996-2008**




(Source: Royal Society 2011)

**Table 1.1. Real-terms income from all sources (GBP M) from 2003 to 2011**

| | 2003-2004 | 2006-2007 | 2010-2011 |
|---|---|---|---|
| **Collaborative research** | 645 | 736 | 872 |
| **Contract research** | 688 | 862 | 1,053 |
| **Consultancy** | 251 | 317 | 370 |
| **Facilities and equipment-related services** | 95 | 102 | 129 |
| **Continuing professional Development and continuing education** | 352 | 534 | 606 |
| **Intellectual property (including sale of shares)** | 46 | 64 | 69 |

**Table 1.2. Outputs from UK HEIs**

| | 2003-2004 | 2006-2007 | 2010-2011 |
|---|---|---|---|
| **Patent applications** | 1,308 | 1,913 | 2,256 |
| **Patents granted** | 463 | 647 | 757 |
| **Formal spin-offs Established** | 167 | 226 | 268 |
| **Formal spin-offs still active after three years** | 688 | 844 | 999 |

(Source: 2003-2004 to 2008-2008 HEFCE HE-BCI collection and 2008-2009 to 2010-2011 HESA Finance Statistical Return collection: HE-BCI)

## CHAPETER FOUR[3]

### 4 Overview of Japanese Corporate R&D in UK

As described in the previous Chapter, the expansion of internationalisation of R&D in UK has been induced by domestic policies in terms of university reform and international competitiveness through drawing foreign investment employed by the Thatcher Administration. With a rise of globalised knowledge economy throughout the last two decades, fundamental rules of translational management have been completely changed. The companies featured by their translational management take specific responsibility determined by their head quarter in home country. Looking into the Japanese companies based in UK turn out to prominent examples showing the fact that they have increasingly put their top priority in absorbing external resources through utilizing their alliances. Their goals are to seek knowledge and market needs from abroad to build competitiveness. They are strongly keen to be engaged with a global network underpinned by their subsidiaries and collaborative companies as a part of their alliance in order to create competitive advantages.

### 4.1 Background of Investment towards UK

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[3] This chapter is the revised work of author's publication; 'The role of geographical proximity in university and industry collaboration: case study of Japanese companies in UK' in International Journal of Technology Transfer and Commercialisation, Vol. 12, No.1/2/3, 2013.

Japanese investment to UK was galvanized by the Japanese electronics companies in 1970s. Sony, Hitachi, Toshiba and Panasonic settled up television and video recorder plants in the 1970s. In the following decade, the second wave of investment from Fujitsu and NEC who built the semiconductor plants. Thereafter, Japanese automobile companies started investment in the mid of 1980s. Auto companies such as Toyota, Nissan and Honda have a huge impact on British economy in terms of creating new jobs. Nissan became the first one who opened its factory in the North East in 1986 followed by Toyota and Honda in 1992. Faced with the fact that European Single Market was due for completion in 1992, Nissan opened European Technology Centers and Toyota opened new engine plants (Turner 2011).

The collapse of Japanese bubble economy in 1990s did not substantially slow down the growth of Japanese inward investment. Japanese companies went under increased competitive pressure during that period. Yet, throughout the 1990s, they expanded their activities both quantitatively in terms of numbers of Japanese-owned operations) and geographically, with a distinct peak in 2003. New trend in that period was that those electronics giants such as Toshiba, Hitachi and Sharp opened R&D centers focused on specific targeted technology areas, which the UK has particularly high capabilities in terms of scientific resource and human skills.

Looking into Japanese FDI using geographic information system (GIS) analysis techniques demonstrates that geographical distribution of Japanese direct investment between 1991 and 2010 has been concentrated in certain areas (Table 2.1). Specifically, strong concentration of Japanese investment cases can be observed in London, in particular inner and Western London towards neighbouring regions such as Hertfordshire, Berkshire, Surrey, Hampshire and Milton Keynes. Another agglomeration can be found in the North East, where firms have spread from the Sunderland region into bordering Tyneside, Northumberland and Durham. The majority of investment cases are indeed within a 20 km radius of Sunderland, coinciding with the presence of Nissan Motor Manufacturing UK.

Moreover, the Greater Manchester regions exhibits sustained Japanese investment profile. Throughout the period, a variety of local government incentives and schemes were employed to channel inward foreign investment towards specific regions of the country. Their aims were to achieve certain national economic objectives and economic recovery and rejuvenation of particular regions. However, there is very limited successful stories of assisted area schemes facilitated by those government incentives have a very limited impact on the determinants of location choice of Japanese companies (Buckley et al. 2013)

As for more recent figure, Japan's outward investment to UK in 2011 amounts to over 1 trillion-yen that is the second largest amount next to the United States. The major investors are Toyota, Nissan, and Honda. In 2012, Hitachi made a contract with the UK Government in terms of supply of railway vehicle mainly for Intercity Express Programme (IEP) and Hitachi acquired the UK company which is planning to build nuclear power plant. The total number of Japanese companies based in UK is 1,100 that is second to Germany. The total number of employees led by the Japanese companies is over 130,000 that reaches the largest share of 30% in EU. It is estimated 88 new projects under Japan's outward investment that is expected to create 7,818 new jobs.

### 4.2 Performance of Japanese Companies R&D with Higher Education Institutes

According to UK government organisation, namely UK Trade and Investment (UKTI), approximately 153 R&D centres and design centres are owned by Japanese companies. In order to grasp the ongoing university and business collaboration between Japanese companies and local UK universities, the questionnaire was first sent out to 153 Japanese companies with support from the Japanese Chamber of Commerce and Industry in the UK and the British Embassy Tokyo. In order to raise a response rate, the author directly contacted those companies deeply involved with collaborative R&D with local HEIs.

The survey was composed of 26 questions designed to investigate basic company information such as the number of years the company has been in business, the number of employees, and the type of business. Additionally, the questionnaire explored whether they have links with UK universities and, if so, what type of collaboration they are doing, what benefits they gain from such collaborations, and what factors concern them most when selecting their partner universities. (Appendix 1&2)

Based on the available resources in the British Embassy Tokyo as well as website and telephone interviews, it is estimated that about 30 of those companies have been involved with advanced R&D activities in UK and launched collaborative R&D with local academia.

The questionnaire was distributed by the Japanese Chamber of Commerce in May 2012. The response rate was about 31%; 46 companies out of 153 replied to the questionnaire. In which, 23 companies replied that they have multiple R&D links with local HEIs. More specifically, 3 companies are geographically most close to the partner in the format of embedded laboratory which own their R&D facilities on partner's campus. 8 companies are tenant companies located in science parks which are especially well designed for research intensive companies to access to local top university owned facility and human resource. The rest of them have their R&D laboratories located at an independent site and far from academic community under such circumstances, a daily face to face contact is not easy and very limited physical access to partners' research facilities. The Table 2.2 shows the list of all companies based on campus (hereafter abbreviated by C); those as tenants of science parks (abbreviated by S); and those companies established on an independent site (abbreviated by I).

The author applies the statistical analysis of non-parametric analysis, specifically the Mann-Whitney test and Principle Components Analysis (PCA) for categorical data to elucidate incentive factors to identify the academic partners and examines the positive impact of geographical closeness on overall R&D and commercial affairs.

Beforehand, the author carried out the interviews with senior managers working at Hitachi, NEC, and Mitsubishi Electronics. The selected companies are all leading giant electronics consumer companies and their UK R&D centres play as a hub of European headquarter. The common feature of these companies is that they are the most proactive actors among other Japanese subsidiaries in terms of research collaboration with local UK HEI. Given such a fact, the aim of the interviews is to clarify the knowledge-based network with local scientific communities, and to what extent such companies utilise advantages derived from geographical proximity. The next section delineates the overview of the above three companies based upon the interviews completed by the author.

## 4.3 Summary of Interviews with Japanese Companies

### *4.3.1 NEC located in Independent site*

NEC's overseas business that is around 16%, worth 550 billion yen. Most of NEC's international collaborators are US and German companies. A small number of UK companies have been involved with NEC through the EU program since FP6. NEC has an alliance with Fuji Heavy Industry and Subaru. (In the latter case, it carries out research focusing on hybrid cars with NEC's battery technologies). Although NEC already has an office in the UK, people at the Central Research Laboratories don't have a good antenna to get the information they really need. NEC is interested in acquiring certain areas such computer software, communication, and networking. The NEC LSI unit has already collaborated with the UK company, ARM, in the area of SoC. NEC has strong interests in the UK S&I, and particularly in the function of Research Councils such as EPSRC and KTNs which are related to the ICT sector.

NEC laboratories in Europe, namely in Germany and the UK, established 15 years ago have focused on the mobile internet, next generation internet, internet service, parallel processing, high performance computing, and standardization. Traditionally they have been doing well in network business (Communications infrastructure) overseas, but they would like to do more with IT, another pillar of their businesses. For instance, NEC have already world-class key technologies such as face recognition, fingerprint recognition (in this, they have one-third shared worldwide), but still they need partners to start local IT business.

NEC is enthusiastic about further global expansion considering an increasing importance of open innovation systems to facilitate science-based technology innovation and intellectual capital portfolios. The direction for future technologies that the NEC group needs to pursue are determined by the technology strategic committee consisting of top managers and the intellectual capital R&D unit which will launch development by forming collaborations for each business unit. All business units and research laboratories have a Chief Patent Officer who is responsible for planning intellectual capital strategies and specific programs. The NEC group holds approximately 72 thousands patents and updates these in accordance with the condition of growth strategies, technology development, and product life cycle. NEC CRL consists of 40 technology research units currently conducting 60 research projects. Once a year top managers of each unit gather to examine and select the most important technology.

As exemplified by the development of the Internet and mobile phones, the integration of computers and communication has been realised in recent years. The environment surrounding these areas has been changing extremely quickly and will continue to do so in the foreseeable future. As next generation networks will be developed, it is estimated that such integrated technologies will become high profile. In response to the rapid technological changes, a combination of science-based technology innovation and intellectual capitals appears to be a key agenda. It is becoming more important to see the tide of IT and network technologies with a longer view. NEC strives to focus on technology and intellectual portfolios underlining the notion of “open innovation” through facilitating collaboration with other institutes and good researchers outside the company.

NEC European Head Quarter used to be just the operation to sell the products made in Japan to the European market. However, now they are shifting from selling company to marketing company, which would add value locally in Europe. NEC used to run overseas operations ‘business unit by business unit’, but now they have shifted to a new scheme encompassing five pillars of the global market, North America, European.

Along this line, in 2014 NEC established a Global Safety Division, which is their first overseas division. This division is going to do proof of concept type projects using Big Data collected from sensors. As for the UK business, they are focusing on public-private collaborative areas such as police wireless communications services, and railways and /or tubes broadband. They are particularly keen to be committed to expand European business with Cloud/IT being the core. NEC chose Germany for their core European

R&D lab because there was established relationship with Heidelberg University with research on super computer and network. NEC R&D in UK has just started their collaborative research on smart water management with Imperial College. A senior manager of NEC sees some future possibility to set up a laboratory in the UK if their collaboration goes well.

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*4.3.2 Mitsubishi Electric located in Science Park*

Mitsubishi electric has already explored collaboration with key UK universities. The Mitsubishi Electric Information Technology Centre Europe is known as the Visual Information Laboratory (VIL) located in the University of Surrey’s Research Park at

Guildford. VIL is working on intelligent visual surveillance systems and automotive digital telematics/infotainment & radar systems to market through working closely with Mitsubishi's Business Divisions. Though not at this particular stage yet, Mitsubishi seemingly maintains an existing healthy relationship with the UK rather than intensifying it.

Mitsubishi Electric R&D Center Europe B.V. (MERCE) located on Science Park in Guilford has 20 local and Japanese researchers. The main areas of R&D include visual information, heating and air conditioning technology, environment friendly research. MERCE has been focusing on its research in the areas of 1) visual information/digital technology and 2) air-to-water technology in the past few years. This R&D enter is currently revising its priority area of research and shifting its focus from digital technology to environment friendly technology/product that is drawn from and developed further from its successful air-to-water low-carbon technology research (In the air-to-water system, air compression technique is used instead of fuels like gas/oil in transferring heat in outdoor air to water heating inside rooms). This air-to-water technology is one of the highlights of the Mitsubishi's businesses, which has been strengthened with the continuous support by the UK Trade and Investment regarding the new investment of air-to-water air-conditioning production in Livingston as it had helped generate synergy between manufacturing, sales and R&D.

In shifting the research focus to environment friendly technology/product, research on water quality, for instance how to remove white lime scale from equipment has been actively conducted. MERCE is about to apply for IP on its eco-friendly technology in collaboration with a university in Cambridge (seem to be on technology related to water quality, ut this information is highly confidential and Mitsubishi is unable to disclose further information for now.

MERCE is now at the stage of researching what comes next further on to the one on water. Moreover, not only technology research but also design development has been operated at MERCE, i.e. much simpler design and function of an air-conditioning remote controller that fits to European consumer taste. Thus MERE is holding discussion of whether they should relocate their research based to Scotland or not, taking into account the proximity to the already existing manufacturing base on M-ACE in Livingston. In addition, having strong connection to researchers at Surrey University excelling in digital technology areas, most of the 20 staff members of MERCE are currently from Surrey University. MERCE is now interested in further collaborative R&D opportunities with other academic institutions as well in transforming its research focus. MELCO has already stationed a senior Japanese staff at MERCE for pursuing collaborative R&D opportunity and relocation possibility within the UK. Mitsubishi is not yet able to feed them on its clear timeline for the relocation project, but there might be an opportunity of employee expansion in association with relocation and/or in the process of collaborative R&D with UK universities. Senior General Manager, Human Resources, European Corporate Office sees potentials and merits of collaborations with UK universities provided their high quality research, as the case of MELCO's laboratory operation in collaboration with MIT and Harvard in Boston, USA.

### *4.3.3 Hitachi Cambridge*

Hitachi's corporate laboratories are positioned as a hub in the Hitachi Group network to strengthen group-wide cooperation between the various R&D divisions. R&D within the Hitachi Group is supported by the corporate R&D Group of laboratories and the divisions within business groups and Group companies where products are developed directly. Hitachi has been promoting research and development, intellectual property, and business as a triad of strategies.

Hitachi's R&D investment is being focused on strong businesses to facilitate early commercialization and generate profits. Information and telecommunication systems had the highest rate of expenditures of sales, followed by digital media & consumer products and high functional materials and components.

In 1989 Hitachi Cambridge Laboratory was established as its first attempt to develop R&D lab in Europe with a strong aim to focus on advanced electronics technologies. It is a so-called embedded laboratory in the Cavendish Laboratory at Cambridge University, which has produced more than 20 Nobel Prize winners in physics. No other Japanese subsidiary in the UK had a laboratory physically located on the Cambridge campus at that time. The decision was made as part of Hitachi's global strategy with the aim of conducting research on next generation electronics and optoelectronics devices with totally new concepts. Hitachi Cambridge was expected to be the core research headquarters among three other R&D centres in Ireland, France, and Italy.

Hitachi made its first contact with Sir Sam Edwards, the Head of Cavendish Laboratory, and sought his direct advice regarding future potential partners in UK universities for future collaboration. Professor Roger Needham led Hitachi's collaboration with Cambridge. Hitachi's collaboration with Cambridge could not have been achieved without the Microsoft Research Centre (MRC). Hitachi rented a research space in MRC and started research collaboration under the supervision of Harun Armaid, who was Head of MRC at that time. They met once a week to discuss research.

The Hitachi–Cambridge collaboration is profitable to both parties. Hitachi Cambridge offers advanced measurement and characterisation techniques that expand the experimental research capability in the Cavendish Laboratory. The University, through collaborative projects, makes state-of-the-art micro- and nano-devices accessible to Hitachi researchers. The Hitachi Cambridge shares facilities with the Microelectronics Research Centre and promotes joint workshops and research programmes with many research groups in the Department of Physics.

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The initial stage of research themes in Hitachi Cambridge included nanotechnology, microelectronics and super computers and then expanded to computer architecture and communications. Throughout the 1995 to 2005, Hitachi HQ decided to expand research themes in digital media, supercomputer and software, telecommunication and wireless, storage solution and life science. Along with this line, Hitachi Cambridge explored the wide range of research areas such as spintronics, organic nano electronics and quantum electronics. In the field of spintronics, for instance, Hitachi Cambridge has research links with Nottingham, Oxford, the Rutherford Institute, Queen Mary College, and Queen Mary University of London.

In 2006, as part of the initiative to establish a direct link between R&D capability and profit generation, over 300 research personnel were assigned to the business divisions to speed-up product development of flat panel TVs, hard disk drives, and other products. This is the time Hitachi HG decided to intensify the collaborative R&D with Japanese universities.

Doctoral students working closely with Hitachi Cambridge are encouraged to apply for scholarships in the form of CASE studentships, which are funded by the UK research-funding agency, Engineering and Physical Sciences Research Council (EPSRC). The CASE studentship is especially designed to enhance collaboration between academics and industry. Hitachi Cambridge became the first Japanese company to win the EU project, SPRIT programme, in 1997. This incident was the subject of political debate, and the mass media reported Hitachi’s success with the critical comment that the EU provided financial support for Japan.

In 2012, Hitachi announced their new strategy for international R&D, trying to boost international operation and UK stays as their top prioritized country to expand local experts. There were about 35 staff in total in Hitachi Cambridge Labs and small other labs in the UK. By end of FY2012, Hitachi increased to 50 staff. In a due course, management including budget was led by Japan R&D HQs, but operational decisions/works such as recruitment etc will be led by a general manager of Hitachi Cambridge Labs. Since 2012, Hitachi has been looking at Europe as one of attractive markets to explore for infrastructure business and keen to find research collaborators expertise not only from Cambridge but also University College London, and Oxford.

Compared to other ICT companies in UK, Hitachi dedicates the higher level of autonomy to the local senior managers affiliated to the subsidiary in UK. Since then

Hitachi has been keen to work on infrastructure projects such as electric power and railway systems as well as information technology-related project such as data centers. The above announcement in 2012 was Hitachi's first major R&D reorganisation in 25 years that comes as the company pins its hopes for long-term growth on what it calls "social innovation" businesses. More specifically, their public infrastructure projects include electric power and railway systems, as well as information technology-related fields such as data centers. In its three-year business plan through March 2013, Hitachi plans to spend half of its Y1.2 trillion research and development budget on its social innovation businesses. The company also aims to boost overseas sales to account for more than half of its group sales in the fiscal year through March 2013, from 41% in the last fiscal year.

In 2013, Hitachi established the European Big Data Laboratory at the University of Manchester which is focused on health, future cities and energy applications. Currently there are 10 staff but this is expected to grow over the longer term; there is also a Global Big Data Lab in the US. Other Hitachi big data analytics applications were discussed: production process control, anomaly detection, large scale surveillance systems, moving image detection & similarity based image search. Hitachi is particularly interested in the overlap between social science and data science, and also keen to work with UK Data Science Schools. Hitachi has signalled a change in direction regarding collaboration with more emphasis on working with other companies and specifically with start-ups which represents a significant opportunity for the UK.

In early stage of their investment, multinational companies from U.S. Germany and Japan tend to utilize accumulated competitive advantages in home countries and based upon them, they exploited overseas market and expanded global business. Nowadays, however, it is unlikely to perceive competitive advantages of one nation state and domestic innovation cluster can be sustained for a foreseeable future. Doz et. al. succinctly demonstrate that traditional global strategies taken by multinational companies are no longer sufficient to differentiate leading competitors, what the knowledge economy means for managers, and why opportunities to leverage globally dispersed knowledge are growing.

The growth of Japanese electronics and ICT industry declined during the 1990s featured by the entire stagnated economy. Most of the Japanese electronics companies were faced with financial shortage and cut down their fundamental research. It is not unusual case as exemplified by the semiconductor industry once featured by the Japan's flagship industry used to take over the lead other competitive countries rapidly lost international competitiveness in the following decade.

Under such circumstances, Japanese giant electronics companies invested in UK such as Hitachi, Mitsubishi and NEC in the last decade gradually transferred their strategies. With rapid changes, an IT revolution and an increase in various demands from users in aubiquitous society, more and more companies have shifted their priority to more comprehensive research and promoting academic-industry collaboration. Such a trend reflects their international R&D in particular those being based in UK.

### 4.4 Summary of Results of Questionnaires

*Descriptive and Statistical analysis*

Twelve of the 23 companies which have R&D collaboration with local HEIs are electronics and communication firms. About 74% were established more than 16 years ago, which implies that they moved in the late 1990s when inward investment from Japan to the UK became popular.

One of the questionnaires asked how they determined partnering universities. The majority of companies replied that they relied on internal personal linkages. Moreover, about 60% (14 companies) replied that they were willing to intensify collaboration in near future.

The results of the questionnaires shows that Japanese tenant companies in science parks and those on university campuses have a strong tendency to carry out collaborative R&D with local HEI over longer time spans compared to those at independent site identified as I companies (Table 2.4).

One question was designed to investigate the determinative factors in the identification by Japanese companies of research partners in HEI. Eleven answer options were given to the respondents. The companies were asked to check all that applied and to rank their answers on a scale from 1 to 4: not at all (1), limited (2), moderate (3), and significant (4) (Table 2.5).

Most Japanese companies perceived good research reputation and facilities as the most important determinants in selecting the best partners among local HEI (Table 2.5). It is noteworthy that starkly different responses among the C, S, and I companies were observed for the item, rich experience in working with industry, as demonstrated by non-parametric analysis. The Mann-Whitney test of non-parametric analysis, which is one of the developmental studies considered as well-known Wilcoxon rank sum test found statistical differences (p value and significant level: $0.047 < 0.05$). The majority of C and S companies perceived rich experience in working with industry significantly important, whereas the I companies' responses to this item were moderate.

Another interesting result was observed in the respondents of the S companies. Japanese companies that are science park tenants have a strong tendency to name patent rights as a benefit. About 70% of them saw obtaining patent rights as the most significant benefit. On the other hand, only about half of the companies classified as being on individual sites saw patents as a great benefit, and the other half saw few benefits from patents. Similarly, it was found that Japanese companies on campuses rarely perceived patent rights as benefits.

One question was posed to ascertain each company's level of satisfaction by measuring the benefits they could obtain from being based in the UK. Similar to the previous question, the respondents were asked to check all answers that applied and to rank the answer in a scale of one to four. About 70% (16 companies) saw highly qualified human resources as the most significant benefit, followed by new ideas for product development. Over half thought that their companies had been vitalised and had upgraded the quality of researchers (Table 2.6).

It is noteworthy that companies in science parks and on university campuses showed higher levels of satisfaction, which was statistically demonstrated by principle components analysis (PCA) for categorical data. PCA is a tool for identifying patterns in data and expressing the data to highlight similarities and differences. Since patterns can be hard to find in data of high dimension, where the luxury of graphical representation is not available, PCA is a powerful tool for analysing data. Also it should be noted that one of the main purposes in PCA intends to show the degree of data compression.

The Table 2.7 depicts the ability of description to reach a relatively high ratio of 68.9% (=7.571/11) combined with principle component 1 at 46.5% (=5.120/11) and dimension 2 at 22.2% (=2.450/11). As shown in Table 2.8, principle component 1 shows the level of overall R&D benefits as demonstrated by the large absolute number of coefficients in several items, such as highly qualified human resources, vitalise the company, and upgrade the quality of researchers, in addition to technology transfer from local HEI.

Principle component 2 showed business and marketing benefits demonstrated by the large absolute number of coefficients in several items, such as accelerate the commercialisation of products and marketing.

Figure 2.1 illustrates the levels of satisfaction of all 23 companies. The horizontal axis reflects the R&D benefits and the vertical axis reflects marketing and business benefits. The figure shows that three companies on campus classified as 1 through 3 appear on the right side on the horizontal axis and in the middle position on the vertical axis, which is similar to the other companies. This result indicates that the companies on campus experiences higher levels of satisfaction in terms of overall R&D benefits although satisfaction with commercial and business benefits remained at the average level. With the exception of one company categorised as a science park tenant, who expressed the lowest level of research and business benefits, majority of companies on campuses and in science parks showed steady overall higher satisfaction.

Some previous studies shed light on the geographical advantages of being located close to the university as well as highlighting how intensifying a network with top researchers is critically important. It has been argued that knowledge spill overs from university research to firms are highly located. Likewise, Brouwer et al. (1999) demonstrate that companies based in agglomerated Dutch regions tend to produce a higher number of new products than those located in more peripheral regions. Almeida, Breschi and Lissoni (2001) attribute the faster diffusion of innovation and greater potential for spill overs among geographically concentrated clusters to the tacit nature of some research. They highlight that some degree of personal contact or oral communication is necessary for knowledge to be effectively transferred. With this in mind, it is assumed that companies located in specific areas with high flows of both private and public or academic R&D are more likely to be innovative than firms located elsewhere due to the benefits from knowledge that leaks out from these sources.

In contrast, other scholars explore the limited influence of geographical closeness for Japanese biotech companies when they select their academic partners from domestic universities (Odagiri and Nakamura 2002). The most recent government-funded survey targeted 1,400 Japanese universities and Japanese companies. This study shows a similar result as over half of the universities and companies see geographical proximity as the least important incentive for further collaboration compared to factors such as quality of research and mutual scientific interests to overcome future technological barriers (Nagaoka, Hosono, Akaike and Nishimura 2013).

Interestingly, the literature dealing with the case of the UK finds that R&D-intensive companies appear to give preference to the research quality of the university partner over geographical closeness (Laursen, Reichstein and Salter 2011). One study succinctly demonstrates that UK universities with excellent research bases have been successfully attracting industrial R&D companies. In particular, chemical and pharmaceutical companies are more proactive in working with top scientists and engineers, while automobile and manufacturing companies show a modest level of interest (Abramovsky, Harrison and Simpson 2007). Abramovslky and Simpson (2008) also find that pharmaceutical companies locate their R&D labs in proximity to not merely university research departments but also to science parks where many R&D-intensive and science-based start-up businesses, including UK university spin-outs, are located.

The responses to the questionnaires and interviews gathered in this chapter clearly show that geographical proximity to HEI has a positive impact on the organisational capacity of Japanese companies by enabling them to embed in local innovation networks and utilise the advantages of the excellent research environments in science parks and campuses. Geographical clustering and the proximity of actors are still important for the generation of knowledge transfer and related spill overs. For such companies, geographical advantage still plays a pivotal role in facilitating knowledge exchange, especially when knowledge is “person-embodied, concept-dependent, spatially sticky and socially accessible only through direct physical interaction.” This can be interpreted as meaning that when knowledge has these key characteristics, geographical proximity may strongly facilitate cognitive and social proximity.

**Table 2.1. Japanese investment numbers in regions across the UK (per cent), 2003-2010**

| | 2003 | 2007 | 2009 | 2010 |
|---|---|---|---|---|
| **North East** | 3.0 | 3.1 | 2.9 | 2.9 |
| **North West** | 4.1 | 4.6 | 4.9 | 5.4 |
| **Yorkshire and Humber** | 1.8 | 1.8 | 1.9 | 1.8 |
| **East Midlands** | 3.6 | 4.1 | 4.5 | 4.2 |
| **West midlands** | 4.6 | 5.2 | 5.2 | 5.3 |
| **East of England** | 6.4 | 7.4 | 7.6 | 7.8 |
| **London** | 47.2 | 45.5 | 45.0 | 44.9 |
| **South East** | 19.2 | 18.9 | 19.0 | 18.7 |
| **South West** | 3.4 | 3.7 | 3.9 | 3.9 |
| **Wales** | 3.6 | 3.1 | 2.9 | 3.1 |
| **Scotland** | 3 .0 | 2.5 | 2.1 | 1.9 |
| **Total (N)** | 1,181 | 1,042 | 942 | 849 |
| **Chi-Square(df 10)** | 2381.6 | 1929.2 | 1710.6 | 1527.2 |
| **Asymptotic Significance (99% level)** | .000*** | .000*** | .000*** | .000*** |

(Source: Buckley et al. 2013)

**Table 2.2. The Japanese R&D Links with UK HEIs on Science Parks, Campus, and Independent Sites (as of the year 2012)**

| **Name of Japanese tenant company** | **Partner UK Universities** |
|---|---|
| **On Science Park** | |
| Cranfield Science Park<br>Nissan Motor (Automotive) | Cranfield, Oxford |
| Cambridge Science Park<br>Toshiba Research Europe Ltd. Cambridge (Electronics) | Cambridge, Bristol, Edinburgh |
| Cambridge Science Park<br>Takeda Cambridge (Pharmaceutical) | Cambridge, Bristol, Oxford, Edinburgh, Dundee |
| Wilton Centre<br>Lucite International (Chemical) | Nottingham, St. Andrews, Bristol, Liverpool, University College of London (UCL), Manchester |
| Oxford Science Park<br>Sharp Laboratories of Europe (Electronics) | Oxford, Cambridge, Imperial College, Southampton, Nottingham, London, Brunel |
| Kent Science Park<br>Harada Europe R&D Centre (Automotive) | Sheffield, Birmingham, Kent |
| Surrey Science Park<br>Mitsubishi Electronics (Electronics) | Surrey, Cambridge, Lincoln |
| Wilton Center<br>Teijin Film (Chemical) | Paisley |

| | |
|---|---|
| **On Campus** | |
| Cambridge Univ<br>Hitachi Cambridge<br>(Electronics) | Cambridge, Notttingham, Leeds, Sheffield, Glasgow, Oxford, UCL, Brunel |
| Bristol Univ<br>Toshiba Research Europe Ltd. (Electronics, Telecommunication) | Bristol, Bath, UCL, Edinburgh, King's College |
| Sussex Univ<br>IMRA Europe SA, UK<br>(Automobile) | Sussex |
| Manchester Univ<br>Satake Ccorporation<br>(Manufacturing and machinery for food industry) | Manchester |
| UCL<br>Eisai<br>(Pharmaceuticals) | UCL |
| Cranfield Univ<br>TDK<br>(Electronics) | Cranfield |
| **Independent site** | |
| Shionogi<br>(Pharmaceuticals) | Oxford, Imperial College, King's College, Aberdeen, Strathclyde, Bristol, Cardiff, Barth, Leeds, Manchester, Liverpool, Edinburgh, Dundee, Grasgow |
| Sony Computer Entertainment Europe<br>(Computer games) | Oxford Brookes |
| Shimadzu<br>(Precision equipment manufacturer) | York, Manchester, STFC Rugherford, STFC Daresbury |
| JFE Steel Europe<br>(Steel) | TWI |
| **S**AMCO<br>(Manufacturing equipment) | Cambridge |
| IHI Europe<br>(Heavy electric machinery) | Imperial College, UCL, TWI |
| Jeol UK<br>(Analytical instruments) | Oxford, York |
| Cambridge Display Technology<br>(Chemical) | Cambridge, Durham, Imperial College |
| Fujitsu Laboratories of Europe<br>(Information and communication technology) | Imperial College, Oxford, Glasgow, HPC, Wales, Manchster, UCL |
| NEC Technologies UK<br>(Electronics) | Guilford |

| | |
|---|---|
| KDDI<br>(Telecommunication) | Aston, Bristol |
| Kyocera Denso Sales UK<br>(Telecommunication, Automotive manufacturing) | Bristol, Brighton |
| Mitsubishi Pharmaceuticals<br>(Pharmaceutical) | Glasgow |
| Hamamatsu Photonics UK<br>(Optoelectronics components, modules and instrument) | UCL, Cambridge |
| Toppan UK<br>(Printing) | Oxford |
| Nippon Telegraph and Telecommunication<br>(Telecommunication) | Oxford |

(Source: Author)

**Table 2.3. Classification of 23 companies**

| Classification id number | Name |
|---|---|
| **Companies on campus (C)** | |
| 1 | Hitachi Cambridge |
| 2 | Eisai UK |
| 3 | Satake |
| **Science park as tenants (S)** | |
| 4 | Sharp Laboratories of Europe |
| 5 | Toshiba Research Europe |
| 6 | Lucite International |
| 7 | Harada Europe R&D |
| 8 | Teijin Film |
| 9 | Nissan Motor |
| 10 | Mitsubishi Electronics |
| 11 | Takeda Cambridge |
| **Independent site (I)** | |
| 12 | NEC Technologies UK |
| 13 | IHI Europe |
| 14 | Jeol UK |
| 15 | Cambridge Display |
| 16 | Shionogi |
| 17 | Hamamatsu Photonics UK |
| 18 | Nippon Telegrah & Telecommunication |
| 19 | Samco |
| 20 | Asahi Kasei |
| 21 | Shimadzu |
| 22 | Fujitsu Laboratories of Europe |
| 23 | JFE Steel |

(Source: Author)

**Table 2.4. Length of Collaborative R&D with HEI**

| Answer Options | Response Per cent of C and S companies | Response Per cent of I companies |
|---|---|---|
| Less than 3 years | 27.3% | 41.7% |
| 3-5 years | 9.1% | 33.3% |
| More than 5 years | 63.6% | 25.0% |

(Source: Author)

**Table 2.5. Results of Question:**

**Which factors are most important for you to select UK universities/research institutes?**

| Answer Options | Not at all | Limited | Moderate | Significant | Response Count |
|---|---|---|---|---|---|
| **Good research reputation** | 0 | 1 | 3 | 18 | 22 |
| **Obtain patent rights** | 4 | 5 | 7 | 6 | 22 |
| **Rich experience in working with industry** | 2 | 3 | 8 | 9 | 22 |
| **Geographical convenience** | 0 | 10 | 9 | 3 | 22 |
| **Good research facilities** | 0 | 1 | 6 | 15 | 22 |
| **Improves product development to meet customers' needs** | 4 | 5 | 6 | 7 | 22 |
| **Save R&D costs** | 2 | 8 | 9 | 3 | 22 |
| **Accelerate the speed of R&D** | 1 | 0 | 9 | 12 | 22 |
| **Advantages in the field needed for future business/products/services** | 1 | 2 | 7 | 12 | 22 |
| **Strong personal linkage** | 0 | 1 | 11 | 10 | 22 |
| **Rich network related to R&D** | 0 | 1 | 7 | 14 | 22 |
| ***Answered question*** | | | | | 22 |
| ***Skipped question*** | | | | | 1 |

(Source: Author)

## Table 2.6. Results of Question:

**What are the benefits that your company has obtained since you have been based in UK?**

| Answer Options | Not at all | Limited | Moderate | Significantly | Response Count |
|---|---|---|---|---|---|
| **Highly qualified human resource** | 0 | 3 | 4 | 16 | 23 |
| **Accelerate the commercialisation of products** | 4 | 9 | 8 | 2 | 23 |
| **Marketing** | 3 | 5 | 12 | 3 | 23 |
| **New ideas for product development** | 1 | 0 | 9 | 13 | 23 |
| **Obtaining patent rights** | 2 | 4 | 5 | 11 | 22 |
| **Financial aid** | 10 | 9 | 3 | 1 | 23 |
| **Technology transfer from local university/research institution** | 1 | 4 | 10 | 8 | 23 |
| **Networking/interaction with local companies** | 2 | 4 | 13 | 4 | 23 |
| **Establish a network to gain information related to R&D** | 0 | 2 | 12 | 9 | 23 |
| **Get new ideas that can be difficult to find in your company** | 2 | 2 | 8 | 11 | 23 |
| **Vitalise your company and grade up the quality of researchers** | 2 | 2 | 7 | 12 | 23 |
| ***Answered question*** | | | | | 23 |
| ***Skipped question*** | | | | | 0 |

(Source: Author)

## Table 2.7. Calculation of Model

| Dimension | Cronbach's α | Variance of exposition |
|---|---|---|
| | | Total (Eigenvalue) |
| 1 | .885 | 5.120 |
| 2 | .651 | 2.450 |
| Total | .955 a | 7.571 |

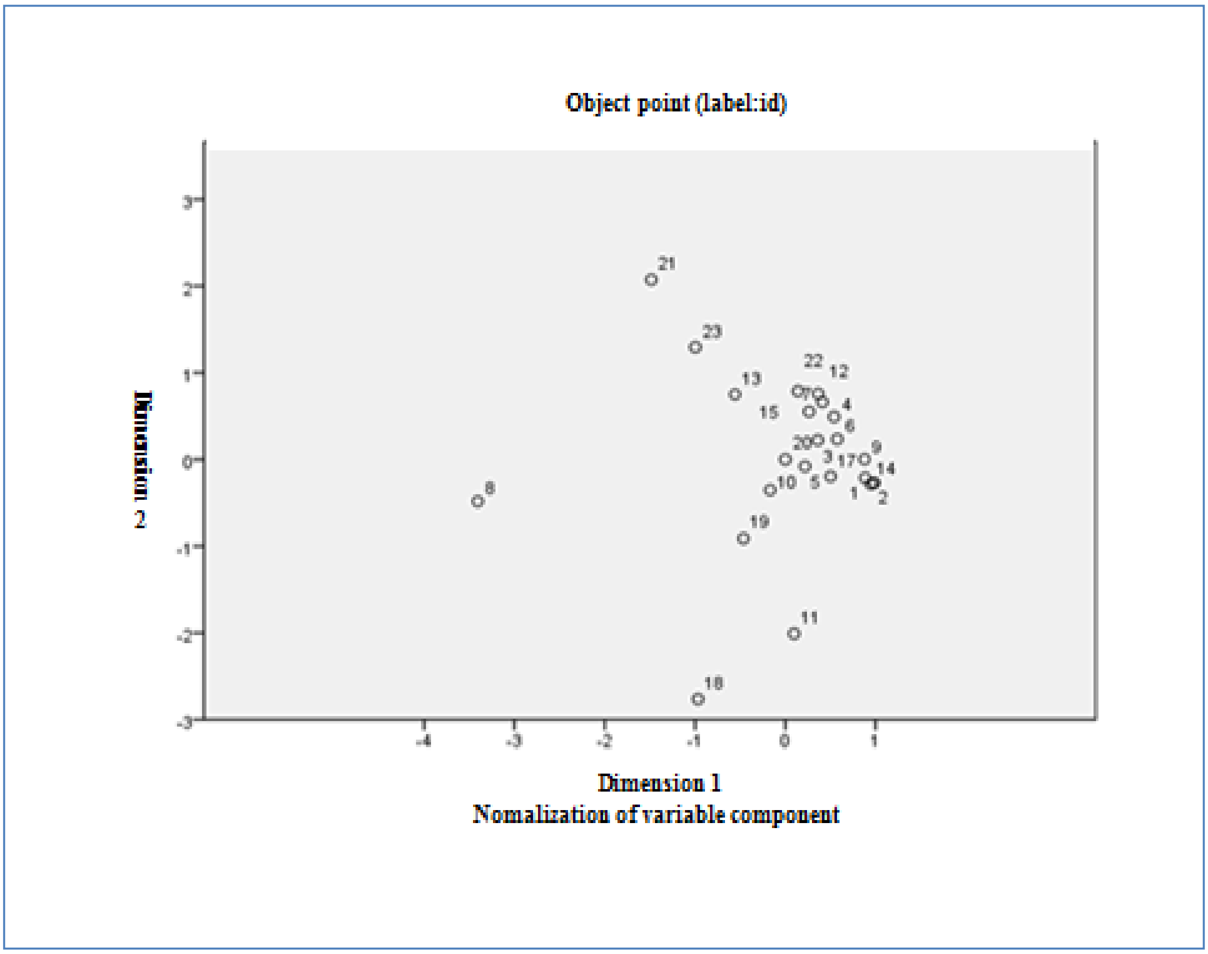
a. Total αof Cronbach's alpha is based on total eigenvalue, which means the index indicating variables information

**Table 2.8. Component Loading**

| Answer options | Dimension | |
|---|---|---|
| | Principle Component 1 | Principle Component 2 |
| **Highly qualified human resource** | .801 | -.023 |
| **Accelerate the commercialisation of products** | .534 | .707 |
| **Marketing** | .560 | .726 |
| **New ideas for product development** | .768 | .444 |
| **Obtaining patent rights** | .722 | -.324 |
| **Financial aid** | .655 | .210 |
| **Technology transfer from local university/research institution** | .769 | -.489 |
| **Networking/interaction with local companies** | .522 | .440 |
| **Establish a network to gain information related to R&D** | .436 | -.552 |
| **Get new ideas that can be difficult to find in your company** | .723 | -.457 |
| **Vitalise your company and grade up the quality of researchers** | .856 | -.358 |

(Source: Author)

**Figure 2.1. Degree of Satisfaction of 23 Individual Companies** [4]




(Source: Author)

## Appendix 1.

[4]Note: Table 1 shows the identification of each company
A
[5]Note: Table 1 shows the identification of each company

British Embassy
Tokyo

**Science & Innovation**
No.1, Ichibancho
Chiyoda-ku, Tokyo
102-8381

Tel: +813 5211 1328
Fax: +813 3230 4800
ukinjapan.fco.gov.uk

**Re: Survey on UK-Japan University-Business Collaboration**

25 May 2012

I am Yumiko Myoken, working within the Science and Innovation Section of the British Embassy in Tokyo. I am writing this letter to ask your cooperation in a survey to measure the performance of advanced companies based in UK, focusing on a linkage with local science bases.

Increased attention has been paid to the significance of open innovation through university-business collaboration for further economic growth in terms of securing the best human resources, knowledge and skills. Your views are very important to increase our knowledge of UK-Japan scientific linkages underpinned by university-business collaborations.

The survey takes approximately 10 minutes to complete. Please answer as many questions as possible. Your positive and negative opinions are gratefully received, and the information that you provide will be held in confidence and will be carefully shared within the Embassy only. Based upon the original data, I am seeking to create some statistical data to demonstrate the impact of such R&D on economic growth and regional innovation for my future research but the name of companies and specific research partners will not be disclosed.

The survey can be accessed from **https://www.surveymonkey.com/s/TC3W62M** I am enclosing the copy of the survey with this letter.

Please complete the survey **before 31 May** through the above link. Thank you for your time in completing the survey. Please contact me should you require further information or have difficulties accessing the online survey.

Yours sincerely,

*Yumiko Myoken*



Yumiko Myoken

## Appendix 2.

**Distributed questionnaire**

1. **Name of your company/organisation**
2. **What is your company status (select)**

    -Independent single site

    -HQ of multi-site UK company

    -Subsidiary of UK company

    -Subsidiary of overseas company (please specify the name of home country)

    -HEI research unit

    -Not for profit

    -Others (please describe)

**3. Age of your company (since you moved in UK) (select)**

-Less than 3 years

-4-8 years

-9-15 years

-More than 16 years

**4. Number of employees in UK (select)**

-Less than 10

-10-30

-30-50

-50-80

-More than 80

**5. Please describe category of business (ex. Information communication, Manufacturing, chemical, electric machinery, pharmaceutical)**

**6. Main activities of your company from 2008-2011 (multiple answers allowed)**

-R&D

-Manufacturing/Assembly

-Sales & distribution

-Training/Teaching

-Testing and analysis/Servicing

-Consultancy/Business support services

**7. Your company is classified as (select)**

-New technology based firms

-Research-intensive company

-None of above

**8. Did you obtain any support from public organisations in terms of your decision?**

**9. Benefits that your company has obtained since you have been based in UK (scale 1-4: not at all, limited, moderate, significantly)**

-Highly qualified human resource

-Accelerate the commercialisation of products

-Marketing

-New ideas for product development

-Obtaining patent rights

-Financial aid

-Technology transfer from local university/research institution

-Networking/interaction with local companies

-Establish a network to gain information related R&D

-Get new ideas that can be difficult to find in your company

-Vitalise your company and grade up the quality of researchers

**10. How often does your company interact with local companies? (select)**

-Almost daily

-About once a week

-About once a month

-Less than above

**11. Does your company have a link with local UK universities/research institutes?**

-Yes, please go to the questions 12-21

-No, please go to the questions 22-24

**12. Please provide the name of UK universities/research institutes you work with.**

**13. Which factors are most important for you to select UK universities/research institutes? (Scale 1-4: not at all, limited, moderate, significantly)**

-Good research reputation

-Get patent rights

-Rich experience in working with industry

-Geographical convenience

-Good research facilities

-Improve produce development that meets with various customers

-Save the cost for R&D

-Accelerate the speed of R&D

-Advantages in the field needed for future business/products/services

-Strong personal linkage

-Rich network related to R&D

**14. How did you decide the partners in universities/research institutes?**

-Through internal survey

-Through internal personal linkage

-Through regional/national agency (please specify)

-Others (please specify)

**15. What type of activities in your collaboration (scale 1-4: not at all, limited, moderate, significantly)**

-Informal contact with academics

-Employment of recent graduates

-Employment of academics on a part time/consultancy basis

-Student projects

-Sponsor research trials or projects

-Access to specialist equipment

-Test/analysis in university

-Grant for new technologies

-Licensing new patent rights

-Assistance by organisation in university teaching programme

-Training by university

**16. Do you evaluate the impact/outcome of collaborative R&D with universities/research institutes? (ex. number of co-authorship, new product development etc) what are the main methods do you use for such evaluation?**

**17. Average length of collaborative R&D with universities/research institutes (select)**

-Less than 3 years

-3-5 years

-More than 5 years

**18. Please describe major outcomes of collaborative R&D contributed to new products, service, and goods (from 2008-present)**

**19. Number of patents you obtained from such collaboration (from 2008-present)**

**20. Sales impact derived from the research outcomes (from 2008-present)**

**21. What is your plan for the future collaboration with UK universities/research institutes?**

-Willing to intensify collaboration

-Maintain the current status

-Less willing to promote new collaboration

-Downsize the level of current collaboration (why? Please specify the reasons)

-Please specify the reasons

**22. Main reasons why you're not working with UK universities/research institutes?**

-Less interests and not necessary for the business

-Less resource and information

-Financial difficulties

-Others (please specify)

**23. What do you think about the barriers for such collaboration?**

-Complicated procedure

-Difficulties to find the right partners

-Less experience

-Cultural difference

-Concerns about confidentiality

-Others (please specify)

**24. Are you planning to start research opportunities with UK universities/research institutes?**

-Yes (please go to Q25 & Q26)

-Don't know yet

-No

**25. How do you find the best partners? (select)**

-Through internal survey

-Visit professors and experts in universities and research institutes

-Seek support from science park office

-Rely on personal network

-Seek support from regional/national agency (please describe)

-Others (please describe)

**26. What type of activities are you expecting? (select 1-4: not at all, limited, moderate, significantly)**

-Informal contact with academics

-Employment of recent graduates

-Employment of academics on a part-time/consultancy basis

-Student projects

-Sponsor research trials or projects

-Access to specialist equipment

-Test/analysis in university

-Assistance by organisation in university teaching programme

-Training by university

## CHAPTER FIVE[6]

### 5. Science Parks in UK and Japan

Relying upon the questionnaire in Chapter Three, 23 companies were identified as the most proactive in terms of collaboration with HEIs. Most of these companies are classified as technology-intensive and are well-known as world-leading innovative companies. About a third of these companies moved into the science park as tenant companies and conducted advanced research and development, trying to fully utilise the advantages of highly qualified research instrument and equipment, and human resources who can offer e tips for business and marketing advice as well as hands-on support for their university-industry collaboration.

The companies that first became tenants in UK science parks are ICT companies such as Toshiba and Sharp. Science parks are expected to realise regional innovation clusters through accelerating technology transfer and intensifying the linkages with local higher education institutes as well as nurturing emerging new technology-based companies.

Today, it is estimated that more than 100 science parks and 3,000 tenant companies

[6] This chapter is the revised work of author's publication: 'Science parks and Triple-Helix innovation in UK and Japan' in International Journal of Technoentrepreneurship, Vol.2, Nos.3/4, 2011.

(10% of which are foreign companies) exist in the UK. Each science park has a distinguished legacy and historical background of trying to become a core actor in regional economic growth. Indeed, science parks have so far produced 75,000 jobs.

The first UK science park was established about 40 years ago in an attempt to foster knowledge-based R&D and to support start-ups (UK Science Park Association (UKSPA) 2006). The number of UK science parks has been increasing, and some of those owned and managed by top UK universities have been successfully attracting foreign tenant companies. Currently, over 100 science parks exist in the UK. Some 10 Japanese companies are identified as tenant companies of these science parks and have intensified their commitment to advanced technology research and development.

UK science parks have grown steadily, as exemplified by the Cambridge Phenomenon. Another huge science park is now under construction in the Greater Bristol area, a hotbed for high-technology industry where a strong triple helix takes place along with the growing internationalisation of advanced R&D activities.

In the last decade, the Japanese government has emphasised the need to forge triple helix links to achieve technology-based innovation. Struggling to find new scientific ideas and resources from higher education institutes, an increasing number of Japanese companies have recognised the need for open innovation. Key policymakers in the public and private sectors have become immersed in reforming the structure and function of the oldest and largest science park in Tsukuba Science City, which has generated enormous scientific outcomes but little economic impact.

The following paragraphs investigates the features of UK and Japanese science parks, delineating how the Cambridge and Tsukuba science and technology parks developed, and discusses what lessons from Cambridge might be of relevance to other regions and countries. Unlike previous studies, which have focused on firms' performances and productivities, this study discusses the significant factors to be considered by key policymakers in both the public and private sectors during the early stages of developing their vision for future science parks.

### 5.1 Definition and Expected Roles

There is no consistently accepted definition of a Science Park; its structure and function gain their features from the distinguished structure of industry and economy in each different country. There are several similar terms used to describe similar developments, such as ‘Research Park’, ‘Technology Park’, ‘Business Park’ and ‘Innovation Centre’ (Monck et al. 1988). Respective countries clarify the definition of science parks by related public associations.

The origin of the first Science Park goes back to the 1950s when the industrial park was established in the USA. It was required in response to a rise of sophisticated industrial activities and an increase in the demands for technology transfer from the universities and public research institutes. In the following decade, the US industrial park was renamed as a research park about the same time as the term began to diffuse into the UK, and thereafter, the name of science parks gained common usage in the UK.

The first science park in the UK was established on the premise that technology-based firms would grow more quickly if they were on the same premises as academic researchers. The role of science parks is to cover more entrepreneurial features, enabling the creation of new businesses as incubators as well as providing the catalytic incubator environment for the transformation of pure research into production

(Westhead and Cowling 1997). In UK, it is understood that science parks developed and have evolved around a science and technology base rather than around a production base with a strong aim to attain innovation.

On the other hand, the term of science parks in Japan is often interpreted narrowly. Japan's National Institute of Science Technology and Policy (NISTEP, 1995) defines science parks as spaces maintaining incubation facilities within the park to support the creation of new enterprises and they own relatively large spaces. Thus, science parks allow new companies to set up new offices or expand new business activities.

Science parks are constructed near universities and a cluster of research institutes. According to the classification given by NISTEP, there are two parks, aside from science parks, namely R&D parks and innovation centres. R&D parks aim to create a cluster of research facilities and institutes combined with universities and private and public R&D bases but without any facilities for incubation. And, the innovation centres hold incubation facilities intended to promote new businesses. Mostly, the innovation centres are located in metropolitan areas, working closely with universities and higher education institutes nearby and with public institutes.

The statistical survey carried out by NISTEP finds that 111 science, R&D parks and innovation centres exist in Japan. The R&D parks have the largest share (41%), followed by science parks (33%) and innovation centres (26%). This result reflects that majority of Japanese science and technology parks put less priority on the issue of how to create new business.

**5.2 UK Science Parks in Cambridge and Bristol**

A number of UK science parks have grown rapidly since the last decade. From bottom-up initiatives, science and business community have attempted to employ strategic policy enabling a triple helix linkage in science parks, seen as an essential tool to acquire advanced technology-based innovation as well as to accelerate commercialisation of advanced technologies developed in university laboratories.

The UK Science Parks Association (UKSPA), a key public organisation dealing with all the responsibilities regarding science parks in UK, has become very keen to upgrade the quality and function of science parks. The mission of UKSPA is to raise the standards of science parks' provisions through an inclusive membership policy and to improve services, making UK science parks a distinct property and business development offering, more than a real-estate initiative.

The UK owns a world-class network of science parks and business incubators that specialises in supporting businesses to promote and commercialise leading-edge technologies. There are more than 100 science parks with nearly 3000 tenant companies (including over 300 overseas-owned companies) reaching over 1.5 million m2 of property. Employment in companies located on UK science parks has risen from 26,000 to 73,600 over the last 10 years (UKSPA 2010). UK Science Parks are owned by various organisations such as universities, local governments and private management companies. Cambridge has grown as the most successful science park in the UK in terms of productivity and commercialisation of emerging new technologies.

*5.2.1 Cambridge Science Park*

Cambridge Science Park, as the first science park in the UK, was established in response to the 1969 University Mott Report (by Sir Neville Mott, then Cavendish Professor of Experimental Physics at the University). The recommendation of the report encourages a much more pro-active university policy of technology transfer and support for high-technology firms. Significant point is that it is not associated with or run by the central government but was established by Trinity College. Since the park was formally opened in 1975, it has been a success; it houses over 60 high-technology and related companies, including giant companies such as Toshiba and Sun Microsystems, employing more than 5000 people (St. John's Innovation Centre, 2008). St. John's Innovation Park has played a central role in creating small technology start-ups including spin-offs, and in offering business support to other local technology-based firms through its Innovation Centre. The Centre has kept close links with Cambridge University and local government-funded business support agencies with more entrepreneurial approach (Keeble 2001).

Moreover, St. John's Innovation Centre, established in 1987, adopts a flexible and practical approach to carry out arrangements that have allowed early stage companies to grow and flourish according to their particular circumstances. It provides special accommodation for knowledge-intensive and early stage ventures (Table 3.1). The changing nature of the high-tech sector has been reflected over the decades in the make-up of companies and organisations on Cambridge Science Park, which now includes pioneers in dynamic new fields such as mobile communications, genomics, nanotechnology, photonics and materials science. Nishiguchi points out that the opening of M11, a road connecting London to Cambridge, about 80 km, had a positive impact in respect to saving time for travelling (Nishiguchi, 2003). The increasing number of large companies became more particular about the distinguished environment in Cambridge. Recently, aside from the IT sector, biotechnology- and life-science-related companies have gained interest in coming to the Cambridge Science Park.

In June 2008, Building 101, with a £17 m, 80,000 ft2 new-build office, and the R&D building were established. Dutch electronics company, Philips, and a well-known software solutions company, Citrix, have moved in to conduct their research. In addition, Napp Pharmaceuticals, home to one of Cambridge’s Science Parks most iconic buildings, has recently pre-let three new buildings from Trinity College (TSB 2009). The success of the many companies that have grown and developed in Cambridge Science Park has given the site an international reputation for world-leading technology transfer. Industry leading names such as GSK, Glaxo, Hitachi, Microsoft and Toshiba have situated key research and development centres on the site.

For instance, Toshiba has achieved a range of scientific results since its establishment, by closely working with Cambridge academics. Toshiba Cambridge Research Centre (TCRC) was opened in 1991 with a specific mission to conduct R&D on frontier scientific research for semiconductor technology in the 21st century. TCRC was started with Professor Michael Pepper as Managing Director. Thereafter, TCRC was renamed to Cambridge Research Laboratory (CRL) in 1998. New CRL offices of U208 Cambridge Science Park officially opened in November 2007 and welcomed Professor Roberto Cippolla as the new Managing Director (Sata 2009).

CRL has two main research units focusing on quantum physics and nanotechnology, and interactive technology. CRL generated the world's 1st single photon-emitting diode in 2002 and the world's 1st triggered entangled photons emitting diode in 2006. CRL has created core technology for future business and empowered talented researchers to fulfil their potential. At the meeting with senior managers in Toshiba, they emphasised that Cambridge is an attractive city where top-level professors and students come from all over the world. They insist that Toshiba can gain advantages in collaborating with European universities and enterprises as well as strong university support. There is no such stimulus environment in Japan (Sata 2009). Toshiba CRL plays a crucial role as a technology provider, spinning-out the Teraview new venture (Sata 2009). Like Toshiba, other corporate R&D organisations include ARM and Kodak European Research, focusing on joint research and development programmes with universities, companies and other organisations and key technologies in the area of display, commercial printing and health imaging.

Today, the Cambridge Science Park is acknowledged as one of the most attractive destinations for global and new technology-intensive companies. As has been observed, many public and private consulting companies have assisted foreign investors in gaining access to excellent local science communities. This Cambridge phenomenon complies with the concept of the linkage between commercial enterprise and academic research that is central to the UK Science Park model (Quitas et al. 1992). There are formal and operational links with centres of knowledge creation such as universities. Significantly, as Nishiguchi succinctly points out, the following three main factors are raised as main reasons behind huge successes in terms of efficient commercialisation, namely,•long history and past achievements of spin-offs, university employs the system of Intellectual Property Right attributed to inventors•the strong role of Barclay Bank as venture capital in the latter half of 1970s and throughout 1980s (Nishiguchi 2003).

Indeed, there is a number of international entrepreneurship and innovation-related events involving private and public sectors as well as higher education institutes. Various networking organisations provide forums to bring business people, academics, technologists and service providers together. Moreover, nine organisations with the University of Cambridge have high competence to support start-ups, growing and mature ventures and to activate interaction between local start-ups and the University of Cambridge (see Tables 3.2 and 3.3). Strong multiple networks involving entrepreneurs, university academics, local governments and banks have another important role. In such a process, not merely high-tech companies but also lawyers and accountants have reaped benefits in a various way.

### *5.2.2 SPark in Bristol*

In 2005, Gordon Brown, Chancellor of the Exchequer, announced a number of designated science cities, namely York, Manchester, Newcastle, Bristol, Birmingham and Nottingham, in a budget statement (UKTI 2010). Since then, UKSPA has made enormous efforts in supporting the maintenance of high standards of science park provisions in the UK through initiatives for members that help them to develop their knowledge and understanding, to grow their networks and to share good practice.

Much attention has currently shifted towards the emerging new science park in Bristol, called Spark, with an aim to make it create regional prosperity in the knowledge-based economy as well as to induce regional Research-Intensive Clusters (RICs).

Under such circumstances, this new Bristol Science Park, Spark, will be opened in 2011. Bristol is the home base of Concorde and Airbus 380 for UK, and thus, famous for its aerospace industries. Indeed, nine out of the top 12 UK aerospace companies are based in Bristol, appearing as the second largest aerospace cluster in the world. Beyond the aerospace sector, there is a high-technology research centre owned by Hewlett-Packard. There are good, world-class universities, which have strong links with industries. Global giant companies seek a very highly skilled workforce in the greater Bristol area. SPark is directly supported by Bristol University, Bath University, and Western England University as well as by the Regional Development Agency (RDA), SWRDA and a developer, Quantum Property Partnership. The work towards this large science park has just begun, with a 10 million dollar cash injection.

SPark is intended to create 6000 new jobs in Bristol. It is located next to the Bristol greater area and is expected to grow and evolve to accommodate the hi-tech high fliers of the 21st century. Bristol University has rich experience in working with not only foreign companies, but also foreign universities as exemplified by MoU signed by Bristol University and Kyoto University in 2008. The pioneering partnership is between Kyoto University's Innovative Collaboration Centre (ICC) and the University of Bristol's Research and Enterprise Development (RED) division.

Learning from Cambridge's successes, Bristol University introduces a similar mechanism and explores internationalisation of their R&D. Its innovation centre provides highly flexible laboratory and office space, with shared areas and conference facilities to exchange ideas, develop solutions and be inspired. The centre also includes a complete business-support infrastructure helping young companies to grow and, in particular, to access the right advisers, mentors and partners.

**5.3 Japanese Science Park in Tsukuba Science City**

The oldest and largest science park in Japan is Tsukuba Science Park, located in Tsukuba Science City where around a third of public research institutions in Japan are concentrated. Tsukuba Science Park has transformed itself to introduce the structure, function and mechanism of all three categories defined by NISTEP. Unlike UK science parks with bottom-up initiatives, Tsukuba Science Park is controlled by the central government, which is now struggling to make Tsukuba Science Park a powerful place to accelerate technology transfers through forging triple helix linkages. There is no public institute that has full responsibilities for science parks, such as UKSPA in UK, as instead the central government and municipalities are the key actors. Tsukuba has about 21,000 researchers, more than 1,500 of whom are from abroad with the largest share of researchers from China. A range of national leading research institutes, as exemplified by the Advanced National Institute for Industrial Science and Technology (AIST) and the National Institute for Materials Science (NIMS), is concentrated in the city of Tsukuba (Ibaraki Prefecture 2010).

On the basis of the Tsukuba Academic New Town Construction Act, the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT), the municipality of Ibaraki Prefecture, and Tsukuba City have examined and appraised the quality of Tsukuba Science City. For almost 40 years, Tsukuba has been developed under the control of MLIT, which enacted the Tsukuba Academic New Town Construction Act. MLIT is an expert organisation with rich experience in establishing state-of-the-art infrastructures and buildings, although it does not hold a clear vision and strategy for promoting technology transfer and start-ups. MLIT and the local municipality are also trying to form an efficient triple helix linkage and to accelerate the commercialisation of new technologies.

MLIT published a report on examining the growth of Tsukuba and concluded that it has not acted as a catalyst for technology-based innovation as exemplified by the Cambridge Phenomenon. The report states that the main reason behind the failure of Tsukuba Science Park is that its structure relied upon the concept of a liner model, which should thus be changed into a chain-linked mode to accelerate the efficiency and commercialisation of R&D in response to the changed global market (MLIT 2004). Further, key policymakers and academics have argued the need for legislative arrangements and more business-friendly tax credits. Eventually, early this year, a new proposal called the Tsukuba Grand Design was submitted with the aim of upgrading and promoting an open innovation-type new science park intended to create new industries (Figure 3.1). It is designed to accommodate the accumulated sound research achievements of individual public institutes and higher education institutes.

The proposal suggests that new research projects should be designed to encourage further involvement from regional companies in specific fields such as environmental technology, nanotechnology and robotics where Tsukuba conventionally holds competitive advantages (New Tsukuba Grand Design Committee of Ibaraki Prefecture 2010). Moreover, the paper underlines the strong cross-institutional ties, essential for promoting science- and technology-based innovation. Tsukuba is becoming extremely keen to launch an open-innovation type research project with a special emphasis on the commercialisation of life-supporting robots under financial support from the Ministry of Economy, Trade and Industry (METI). This project is led by multiple research organisations based in Tsukuba such as AIST and Japan Automobile Research Institute (JARI) and its aim is to establish safety standards by conducting the safety authentication tests required for further dissemination.

*Tsukuba Innovation Arena*

Following the initiatives of the Tsukuba Grand Design, the central government, METI and the Ministry of Education, Culture, Sports, Science, and Technology (MEXT) began the full-scale process of upgrading Tsukuba Science Park with some support from the Japan's Business Federation, *Keidanren*. They decided to establish a technology centre for excellence known as the Tsukuba Innovation Arena (TIA). The

TIA is intended to create new global business through conducting practical demonstrations in common basic infrastructures. In addition, it is designed to provide an environment-under-one-roof concept beyond each organisation in terms of academics, university and industry, and to expand networks beyond borders to create wealth by strengthening collaboration. It is widely argued that the function of education needs to be improved by forging close triple helix linkages.

With a 36.1 billion-yen grant (300 million Euros) from the Japanese government, AIST, the NIMS and the University of Tsukuba decided to integrate their research capabilities to form a global centre dedicated to nanotechnology innovation. The so-called “TIA nano” project moved into full-swing in April 2010, taking advantage of 30 years of innovations made by advanced nanotechnology facilities. In the field of power electronics, a new consistent trial line of Silicon Carbide, namely the “SiC” foundry, was established to transfer new research findings to manufacturing processes. TIA is intended to adopt measures for the commercialisation of research outcomes.

Equally important, it aims at educating the next generation by strengthening international networking and generating mutually beneficial business and research relationships. Alongside Japanese companies, TIA nano is also very keen to invite foreign companies to establish win-win partnerships.

However, there is only one organisation working on business support for start-ups as well as facilitating cross-sectional networking beyond research institutes. The new vision of TIA nano is less concerned about the lack of organisations within the science park, which owns specific competence to support new technology-based firms and to operate in legal, banking and accountancy areas. Rather, there is a strong tendency to believe that efforts need to be made to build advanced high-tech facilities for the research base and related infrastructures. Fewer efforts are made to nurture experts capable of managing technology transfer through strengthening the linkages between researchers and business and mitigating the barrier caused by sectionalism among various research institutes controlled by different ministries.

The ideal model of TIA nano should facilitate the interaction of various business and academic actors through national projects. In order for TIA nano to pursue truly technology-driven innovation and to accelerate the commercialisation of new technologies, it is essential to recruit specialist staff members who can deal with the particular needs of technology businesses such as banks with specialist technology business managers.

Key policymakers therefore need to identify the best strategies for designing new science parks so that the parks more successfully complement local entities. As seen from the Tsukuba Grand Design and the TIA Nano, few strategies exist to promote personalised aid. In this capacity, the critically important role played by human resources should be emphasised. Human resource departments can offer individuals more personalised aid that focuses on the needs of each tenant and, in doing so, they can facilitate the knowledge flow that arises from universities and institutions of higher education.

The comparative study of UK and Japanese science finds that the growth of a substantial cluster of high-technology firms in UK science parks has largely relied upon the advantages of each city's excellent scientific resources. Of equal importance to that success is the "spontaneous 'bottom-up' phenomenon" led by the network of scientists, engineers and business experts who are willing to facilitate technology transfer and commercialisation. St. John's Innovation Centre in Cambridge serves as one prominent example. This organisation adopted a flexible and practical approach to implementing arrangements for the early stages of the Centre's development, including launching several international entrepreneurships and innovation-related events involving organisations in the private and public sectors as well as in institutions of higher education.

On the other hand, Tsukuba Science Park was originally developed by the central government with the goal of pursuing a specific research agenda. As such, emphasis was placed on establishing state-of-the-art infrastructures rather than nurturing a human network of "gatekeepers". Ultimately, this goal has had an impact on the high survival rate of the park's tenants. Thus, each national institute administered by a different ministry tends to work independently with a vision narrowly determined by its parent ministry. Consequently, Tsukuba Science Park has exerted less effort to shift from being a core space for collective learning to being a contributor to economic and social prosperity.

### 5.4 Interviews with Japanese Companies as Tenant Companies in Science Parks

According to the responses obtained through the questionnaire conducted in the Chapter

3, a strong tendency can be observed in science park tenants to conduct informal contact with academics more actively than non-tenant companies. Another stark difference between tenant and non-tenant companies is their attitude towards the employment of a local highly skilled labour force. Interestingly, science park tenants are more proactive in terms of test and analysis in university while at the same time being no less active in licensing new patent rights (Table 3.4). The following paragraphs provide a summary of four interviews with senior managers who work at Japanese companies that are tenants of science parks, namely 1) Toshiba and 2) Takeda in Cambridge Science Park, 3) Harada in Kent Science Park and 4) Sharp in Oxford Science Park.

### *5.4.1 Toshiba Cambridge Research Laboratory*

Toshiba is Japan's second-largest (after Hitachi) comprehensive electrical machinery manufacturers, employing around 200,000 worldwide, producing a wide range of products from laptop computers through space technology to nuclear power. Toshiba is a diversified manufacturer and marketer of electrical products, spanning information & communications equipment and systems, Internet-based solutions and services, electronic components and materials, power systems, industrial and social infrastructure systems, and household appliances.

Toshiba-made semiconductors are among the worldwide top 20 semiiconductor salesleaders. In 2009, Toshiba was the world 5th largest personal computer vendor, after Hewlett-Packard of the U.S., Acer of Taiwan, Dell of the U.S., and Lenovo of China. Toshiba ceased production of TVs at its factory in Plymouth in August 2009 with theloss of 221 jobs with around 50 posts retained in an engineering support capacity. This followed a review of Toshiba's global TV manufacturing strategy and the decision to centralize the management of European TV production at its factory in Poland.

There have been problems in Poland in keeping skilled staff and the environment for Japanese managers in Poland is less comfortable, for example, with communicating clearly (in a third language). Sales of LCD TVs in the UK are 10 times those of Poland and the second largest in Europe. A senior manager of Toshiba felt that the increased market potential of Russia and Eastern European countries would keep the Poland Plant occupied and did not see the Plymouth Factory closing for a good 3 or 4 years. Throughout the discussion he was putting forward strong evidence for keeping the plant and, apart from mentioning higher labour costs, put forward no negative comments on the plant.

Over twenty years Toshiba has invested in two research laboratories based in Cambridge and Bristol. There are 5 core technological areas; Human Interface, LSI and Storage, Nano Materials and Devices, Mechanical & systems Engineering, Information & Communication Platform Text-to-Speech technology and its recognition, Image processing Technologies, Quantum Cryptography are developed by Cambridge laboratory. High-efficiency power amplifier system and smart grid, secured ICT system are developed by Bristol Laboratory. There outcomes as a result of 20 years operations in the UK are highly appreciated.

Established in 1991, the Cambridge Research Laboratory (CRL) is Toshiba's first overseas corporate-level R&D laboratory. CRL invited Prof Sir Michael Pepper to be Managing Director with the aim of carrying out R&D on frontier scientific research for semiconductor technology. Currently, CRL consists of three research teams devoted to quantum information, speech technology and computer vision. In the field of quantum information, a close collaboration is undertaken with the Cavendish Laboratory, which has produced many Nobel Prize winners in physics. CRL is loosely working with the Engineering Department of the University of Cambridge in the area of computer vision and speech technology. CRL supports doctoral students who work as consultants under student support contracts.

Toshiba is the first private company to establish a fellowship scheme in the UK. CRL launched a fellowship programme in order to gain mutual understanding between the two countries through direct cooperation in leading edge research. The fellowship provides leading scientists with the opportunity to join Toshiba's R&D Centre, working on one of its high-technology research teams in Japan for up to two years. Applications are widely open to researchers from any EU member states who are researching in the UK. The applications are all screened by UK EPSRC. The programme also offers the successful fellow a generous package including a fixed salary and travel to and from Japan. Some students become contract employees through project and task bases. CRL has not only been involved with national projects funded by the UK government but has also proactively participated in EU projects.

Toshiba is the only Japanese company whose R&D is located on both a science park and a campus. The Telecommunication Research Laboratory (TRL) on the campus of the University of Bristol was launched by Prof Joe McGeehan, who is well-known for his excellent research record as well as his achievement in strategic partnerships with industry and academia. He has been a conceptual pioneer of 3G technology and was in a position to develop a lab which drew synergies from both Japan through Toshiba and the very strong British mobile communications community. TRL is now designated as Toshiba's global leader for research on wireless. By 2006, it had received $45 million investment and was employing 30 research engineers and 10 sponsored PhD students on cutting-edge wireless research. TRL has been expanding its partnership with other UK universities such as the University of Bath, the University College London, the University of Edinburgh, and King's College, as well as other companies such as Nokia, Samsung, Vodafone, Fujitsu, NEC, and Kyocera.

The Bristol laboratory focused on telecommunication has 30 local research engineers and 10 sponsored PhD students conducting cutting-edge wireless research. This is focused on four key areas: future wireless broadband systems, architectures and systems for software defined and cognitive radio, approaches for reduction of complexity, and strandisation and exploitation activities. The UK also has a unique vehicle for supporting long-term wireless communication research-the Mobile Virtual Centre of Excellence. This brings leading operators and manufacturers, and a group of leading mobile research universities together, providing a superb backdrop for industry led research in the UK. R&D teams in the UK have the benefit of being able to tap in to the work of the Mobile Virtual Centre of Excellence, which reinforces and enhances their own research efforts.

R&D in both Cambridge and Bristol have been already well connected to the UK academic and research network. New opportunities for more investment/expansion in these R&D activities are possible. Such a decision is determined by London rather than Japan, as there is already high degree of autonomy in the two labs. Both of them are continuously keen to enhance the market intelligence gathering function of European laboratory to obtain forward-looking technological information about European market more and more. In particular, environmental regulation across the Europe and standardization of smart grid are significantly important information to drive their global and European business. 2011 was a memorial year for Toshiba corporate R&D centre because of its 50th anniversary and 20th anniversary of Toshiba Research Europe.

Adding to the matching fund with EPSRC as mentioned above, the Toshiba also runs Fellowship programme available for PhD level researchers with EU nationalities who work in a UK academic institution. This programme is different from recruitment, so researchers can freely choose their further career, working for Toshiba Laboratory, academic institutions, or competitors. There is a fellowship alumni union once a year; this reunion is the place to find out further research collaboration. As for the UK business, they are focusing on public-private collaborative areas such aspolice wireless communications services, and railways and /or tubes broadband.

*5.4.2 Harada Industry – Kent Science Park*

Harada Industry is the world's largest supplier of automotive antennas. Harada Industry has a long-term research collaboration with Professor Richard Langley of Kent University, a pioneer of antenna development. With such a background, the Harada R&D centre was first established at the University of Kent. Only limited space was available on the campus and, as time passed, more space became essential for their manufacturing and research facilities for antenna measurement. Under these circumstances, they decided to move to the Kent Science Park. Three resident staff members were sent from Japan. Harada employed some graduates from Kent University who used to work together on projects.

Currently, Kent Science Park hosts about 60 tenant companies, which consist of chemical companies and insurance and financial companies. The high security system installed in the science park is very much appreciated by companies like Harada, which needs to deal with experimental demonstrations and receives orders from competitive companies. The resulting information should be treated as strictly confidential. For these reasons, there is no company conducting similar tasks to Harada Industry in Kent Science Park. There is a very limited degree of inter-tenant communication and network activities.

Harada R&D had already built a strong personal linkage with the professor from the University of Kent; since then, their priority is advanced research and development. It is easy to access highly qualified and skilled researchers in the UK with relatively low cost compared to the US. Harada is currently looking to form a new partnership with the University of Birmingham. The UK staff rather than Japanese staff mainly deal with identifying new research partners and leading experts through attending scientific and academic conferences. Due to the nature of their dual use technologies, Harada is sometimes involved with UK national projects funded by the Department of Defence. There is no specific measurement or indication for evaluating the outcome of collaborative research with local universities, but the significant point is whether the technologies developed are commercialised and feasible applications for quantity production.

### *5.4.3 Takeda Cambridge*

Takeda Cambridge Research (TCR) had a research link with a company called Paradigm Therapeutics Limited. Established in 1999, Paradigm is an outgrowth of Cambridge University. Paradigm has developed a pipeline of novel drug discovery targets and compounds in key areas of unmet medical need including breast cancer, diabetes, hyperlipidemia, and obesity. Paradigm was established in Cambridge Science Park in 2003. In 2007, Takeda acquired Paradigm and moved to the facility located in Cambridge Science Park.

In 2001, Takeda organised a strategic research planning department, which became the centre through which Takeda's pursuit of globalisation gained momentum. TCR represents one step in the progress of their global strategies. Without any doubt, Cambridge is the centre of biotechnology-based companies and pharmaceutical companies, which makes it a strategically pivotal area. Cambridge Science Park provides such companies with a nice site from which to develop linkages with local universities and hospitals.

About 100 people work in TCR with the primary mission of identifying novel targets. They use chemistry and biology to optimise drug candidates to the molecules. The president of TCR, Dr Mark Clayton, has an extensive network with experts in obesity and metabolic diseases as well as key academics. Takeda has explored a hub with hospitals affiliated with Cambridge University, the University of London, and the University of Oxford, and is also trying to introduce new technologies to academic groups in Italy and Germany, as well as small UK start-up companies. However, TCR is not involved with EU projects and does not obtain any public research funds from UK funding agencies. The recent major collaboration with University College London is particularly focused on oncology for new therapeutic research.

While most of the research topics and themes are determined by headquarters in Japan, TCR has some autonomy in conducting small projects with their own funds. TCR does not have any sponsored research with universities but sometimes works as a consortium.

Local academics work as consultants and advisors to Takeda for six months to one year depending upon the case.

TCR acts as a sponsor of the Royal Society of Chemistry and sometimes arranges academic meetings involving both UK and Japanese chemists. Likewise, TCR has sponsored other academic meetings led by the Royal Society of Medical Research and University of Oxford. TCR has also conducted a contract research with an Indian company located next to TCR.

*5.4.4 Sharp Laboratories of Europe*

Sharp Laboratories of Europe (SLE) was established 20 years ago as the company's first R&D facility abroad. Oxford Science Park opened at about the same time, and SLE became its first external company. SLE was established with Dr Clive Bradley, former Science Counsellor in the British Embassy in Tokyo, as Managing Director. The reason the UK was chosen is that some of Sharp's original patents were owned by UK organisations. The interviewees indicated that the R&D tax credit in the UK is also very encouraging. Sharp's intention was to associate with highly prestigious universities.

London was too expensive, while another Japanese electronics company was already based in Cambridge. The Oxford Science Park was managed by a financial service company and one college, Magdalen College, within Oxford University, with which Sharp already had a good relationship. It also provided easy access to London, which afforded relatively easy access to highly qualified human resources. SLE has about 15,500 $m^2$ of land, which is on lease for 250 years.

The main mission of SLE are to carry out research in those areas in which SLE specialises, namely circuit design, optical modelling, and semiconductor materials and devices. Another important aim is to develop products such as displays for mobile phones and automotives, camera modules, solar systems and lighting systems for Europe. There is another research base in Bracknell and a manufacturing base in North Wales.

Since the beginning of their establishment in Oxford, SLE mixed relatively long-term research in areas such as 3-D electronic display technology with development work on microwave ovens, which fed into Sharp's Wrexham labs. SLE is currently working with three different universities in the field of the utilisation of advanced infrastructure, e-learning systems and 3D displays, respectively. Display technologies have brought about the largest business profits. The research topics are usually proposed by headquarters. Some of the projects involve quite a long time span, looking towards the year 2020, but in one exceptional case there is a request from headquarters for an expected outcome within two weeks or so.

One of the benefits of being based on science parks is recruitment. More specifically, it is easier for SLE to employ and retain highly qualified and experienced researchers not only from Oxford University but from other leading UK research institutes. About 30% of SLE laboratory employees are recruited from Oxford University, Cambridge University and Imperial College London. Additionally, 19 different nationalities are currently represented at SLE.

The pattern of their activities with local universities has been widening, ranging from collaborative R&D, consulting, employing paid students, creating scholarships, dispatching researchers from companies to universities, and intensifying the links with individuals' graduate schools. They sometimes fund PhD students' studies, and they support some contract research, consultations, and intern relationships. Sharp used to support a fellowship programme with the UK funding agency EPSRC (Engineering and Physical Science Research Council), but this project was terminated five years ago.

Sharp has close links with the Royal Society, research institutes such as the Institute of Materials and Physics, and public organisations such as the Technology Strategy Board that are all very helpful in identifying good researchers. SLE has been proactively involved in EU projects by collaborating with research institutes in areas such as Germany, the Netherlands and Czechoslovakia.

As highlighted in the interviews with Sharp, Takeda, Toshiba, and Harada, these companies had strong personal links with UK academia, and have gained some advantages and privileges in terms of R&D tax benefits, human resources, excellent facilities, and related business support. Moreover, these companies successfully explored a wider research network through strong personal linkages, other related research funding agencies, and positive relationships with the scientific community. They were very keen to be involved with EU projects that functioned as hubs of the European research network. While the previous study was based on the supposition that Japanese companies tend to maintain the integrated organisational and business models of their home country, the questionnaires and interviews in this study show that the Japanese tenant companies in science parks have developed their organisational capacity by embedding themselves in the local innovation network and utilising the locational advantages of the excellent research environment in science parks.

**Table 3.1. St. John's innovation centre**

| *St. John's Innovation Centre Ltd.* | |
|---|---|
| Physical incubator | 'Home' for up to 60 high-technology related businesses |
| Virtual incubator | Hands-on support for 500+ non-tenant nascent ventures |
| Rent-an-address | Provides mail and telephone services to 240+ non-tenant ventures |
| High growth start-up services | Supports local companies with business plan development and training in conjunction with University of Cambridge Enterprise, funded by Cambridgeshire Business Services |
| Enterprise link | Networking, events and advice for +600 early stage technology ventures |
| Innovation Relay Centre (IRC) | Gateway to extensive technology business network spanning 30 countries across Europe |

*Source*: Cambridge Technopole Report

**Table 3.2. Business angel groups and networks in the region**

| *Name* | *Overview* |
|---|---|
| Cambridge angels | A business angel group with proven experience as successful entrepreneurs in technology and biotechnology |
| Cambridge Capital Group | A private equity syndicate of angle investors offering funding for early stage technology based companies |
| Great Eastern Investment Forum | Long established business angel network with access to GEIF ventures, a co-investment fund |
| Beer and Partners | One of the oldest business angel networks who may charge for looking at a proposal. National coverage with local offices |
| C2 Ventures | Invest in technology and media businesses |
| E-Synergy | London based group concentrating on early stage technology businesses |
| Norfolk First | Business angel group based in Norwich |
| Suffolk Investors Forum | Provides a direct link to a structured angel network which will invest between 100K GBP and 1 million GBP |

*Source*: East of England Development Agency (2006)

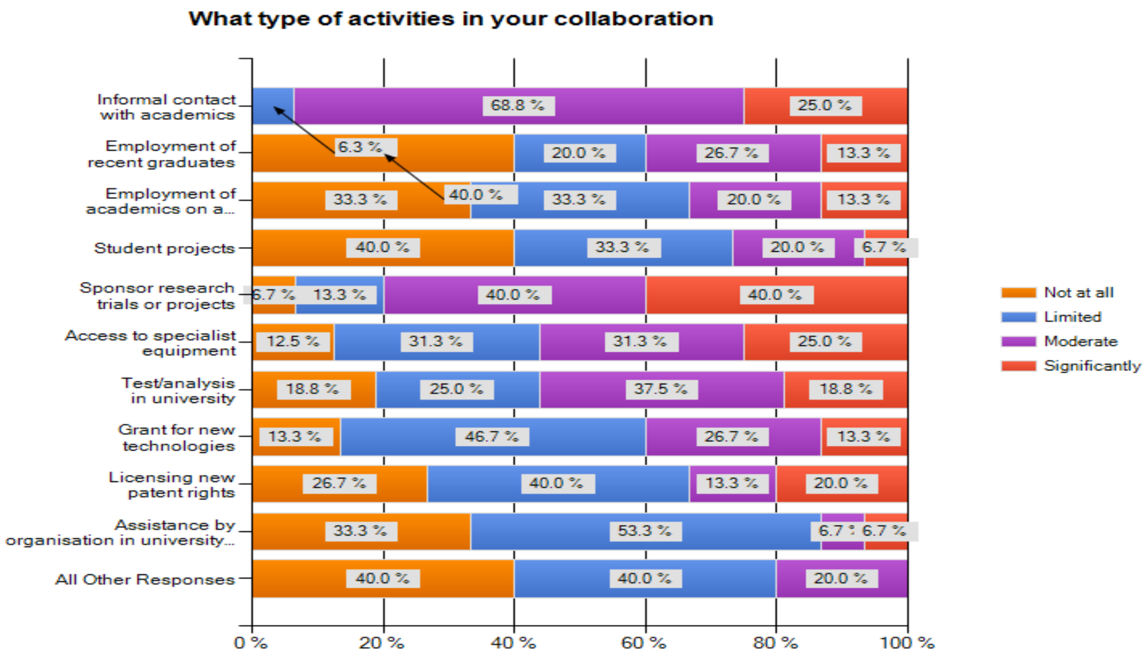
## Table 3.3. Networks and conferences

| | |
|---|---|
| Cambridge Corporate Gateway | Provides companies from around the globe with the opportunity to access both high-technology cluster and University research |
| Cambridge Enterprise Conference | Provides a community for global technology entrepreneurship practitioners to discuss and debate enterprise |
| Cambridge International Manufacturing Symposium | A forum for the exploration of international manufacturing issues |
| Cambridge Summer Forum | A modular programme offering best practice and network with others from around the world in the fields of innovation centres and science parks, university commercialisation, networking, entrepreneurship training and early-stage finance |
| Cambridge Technology Management Symposium | Designed for senior technology and innovation managers from companies of all sizes |
| Horizon Seminars | Provides participants with a first look at new developments in the most exciting areas of science and technology at Cambridge. The events bring together experts from academia and industry |

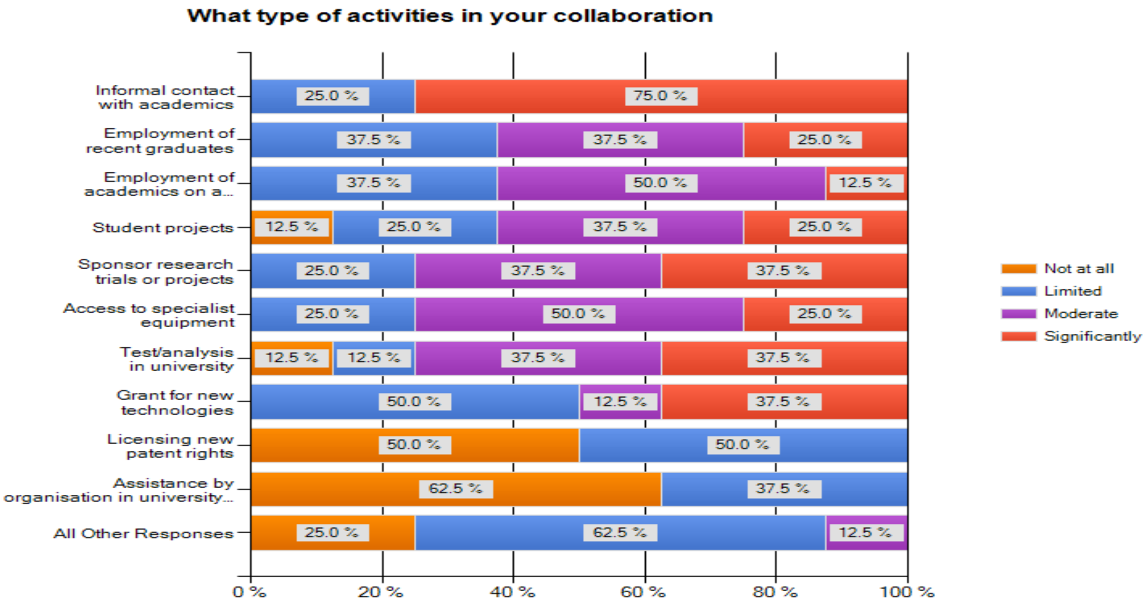
*Source*: Cambridge Technopole Report

## Table 3.4. Type of activities in collaborative R&D with local HEIs

### (a) Responses from non-science park tenants

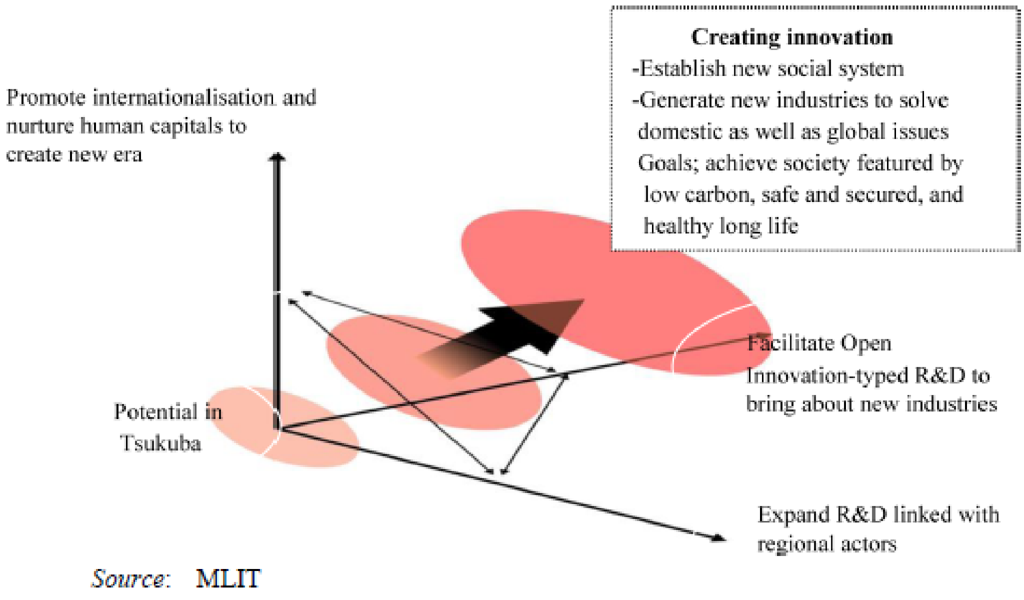



### (a) Responses from science park tenants.




(Source: Author)

**Figure 3.1. Ideas of innovation perceived in the Tsukuba grand design.**




(Source: Author based on figure of MLIT )

**CHAPTER SIX**[7]

# 6. Benefits and Incentives for Academics in UK Universities

## 6.1 Overview of University-Business Collaboration in the UK and Japan

This chapter begins with an overview of the shared interests and agenda for international University-Business collaboration in UK and Japan, reflecting the presentations and intensive discussions at the expert workshop organised by the British Embassy Tokyo. Then, the following section aims to identify the benefits for university professors affiliated with top UK universities, more specifically any impacts on their scientific research and education derived from collaborative R&D with Japanese and UK companies.

In order to define the key questions and identify suitable academics to be interviewees, the author fully utilised the outputs derived from the UK-Japan Workshop, entitled *Building International University-Business Links*, on 10-11 January 2012 jointly organised by Science and Innovation Section in the British Embassy Tokyo and British Council. This workshop offered a unique opportunity to gain an understanding of policy trajectory in both countries as well as common interests and challenges in terms of

[7] This chapter is the revised work of author's publication: 'Investigating the factors fostering sustainable collaboration between Japanese Companies and UK Universities' in International Journal of Business Administration, Vol.5, No. 3, 2014. I.

institutional arrangements and strategies employed by the universities and businesses in both countries.

The UK senior profiles who attended the above workshop agreed to make themselves available for individual in-depth interviews and to introduce their colleagues, as well as senior executives in third organisations such as the university technology transfer office. The findings from the above workshop and additional interviews provide some insights through which to clarify the scope of the planned interviews with UK academics for further investigation. Presenters looked at issues such as policy and support mechanisms in each country, various forms of university-industry collaboration, the role of intellectual property and the nature of successful partnerships. The workshop was attended by 40 Japanese and UK government officials, academics and business representatives deeply engaged in U-B collaboration. The workshop programme is attached at the end of this chapter. The key points and discussions explored at the workshop are summarised as follows:

***Background on U-B collaboration in the UK and Japan: Shared interests and agenda***

- The UK and Japanese Governments' innovation and research strategies rest on studies showing clearly that innovation is essential for economic growth, but that innovation is changing and needs an effective system whereby the actors collaborate both directly and indirectly.

- The costs of cutting edge research are now often too high for one company, and are usually international in nature. It was discussed how U-B collaboration in the UK was increasing, especially among industries seeking to externalise research.

"Industries are always looking around for the best available technologies and are willing to cooperate with universities regardless of location" (Dr Malcolm Skingle, Director of Academic Liaison, Glaxo SmithKline).

U-B collaboration is most likely to start for industry specific reasons such as requiring a technological solution. For instance, a UK academic from the University of Durham noted "the collaboration was established when Sumitomo researchers discovered a gap in their technology and learned from the scientific literature that scientists at Durham were working on this problem and had access to cutting-edge facilities that Sumitomo did not possess. Moreover, there was a market gap because there had been no major new lighting technology for around 75 years, but there was a pressing need to save energy and eliminate the use of mercury. Partway through the partnership, Sumitomo took over a research lab in the UK, and this made collaboration easier" (Prof Andrew Monkman, University of Durham).

- There has been a significant transition, within both UK and Japanese universities, from technology transfer to strategic relationships, as technology transfer through licensing and spin-out companies has not been that successful as either a generator of income or as the most efficient method of technology transfer (Prof Eric Thomas, Vice-Chancellor of University of Bristol, President of Universities UK).

- The UK government is committed to funding a balance of both blue sky and applied research projects. The UK Lambert Review had concluded that British business was not research intensive, and that research was concentrated in a narrow range of industrial sectors. It is argued that collaborations arising from chance encounters could be successful but were usually not scalable. There exist barriers such as the differences in perspective between academics and business (Prof Eric

Thomas, Prof Stephen Holloway, Executive Pro Vice Chancellor, University of Liverpool).

- An academic at the University of Tokyo states that "prior to 2003 inventions in Japanese universities were generally transferred to companies and licensed by the companies, but noted that recently 75% of all university patent inventions have been joint patent applications, which give royalty-free usage rights to the industry partner with no development obligations" (Prof Robert Kneller, Research Centre for Advanced Science and Technology, University of Tokyo). While there are benefits to research from this approach, the drawbacks include exploitation of the outcomes by large industry, and a negative impact on start-up companies. Prof Kneller suggests that licenses should be limited to a specific field of use, so that the IP could be taken forward by others for other fields of use, rather than left unused, and suggested that TLO income should improve through these changes.

One of the sessions was particularly designed to explain the support systems in the UK and Japan, to discuss under what conditions each country could learn from the other, to identify good practice examples in each country and to look at the challenges of implementing them in the other country.

- For instance, as a representative of Newcastle University pointed out, "The importance of providing diverse career options for researchers within and outside academia is increasingly recognised in the UK. Some examples of programmes run in Europe and also at each university. One of the success factors of those programmes is the provision of opportunities for researchers to work in more interdisciplinary contexts so that they can prepare for a diverse range of professions" (Prof Ella Ritchie, Deputy Vice-Chancellor, Newcastle University).

***Freedom in selecting research themes for collaboration***

- One participant asked how much autonomy the subsidiaries have in terms of developing their research agenda and collaboration relationships. The level of autonomy is slightly different in each case but, in general, a bottom-up decision-making process led by local researchers and academics in the UK has been widely appreciated. However, autonomy is still somehow affected by the size of investment determined by HQ in home country.

- One senior R&D manager for Toshiba who used to work at Toshiba Cambridge Laboratory said, "There are several layers in Toshiba's research organisations, and the ideas of the UK academic teams are very much appreciated. One positive aspect of inviting professors to head research teams is to discover what technologies will be important in future Toshiba products" (Dr Yutaka Sata, Group Manager, Planning and Coordination Group, Technology Planning Division, Toshiba Corporation).

- One senior UK academic stated, "Eisai gives a certain amount of autonomy to research groups, but warned that ideas are cheap, noting that there are many hurdles regarding compliance and investment to clear which may need to be approved at corporate level depending on the size of the investment required" (Dr B.T. Slingsby Director Global Partner Solutions, Eisai Co., Ltd.).

**6.2 Impact on UK Scientific and Education Outcomes**

Partially relying upon outputs stemming from the above workshop in January 2012, the author decided to move on to further interviews with the aim of investigating how UK university academics sustain academic freedom in launching collaborative research with Japanese companies moving into the UK. The intriguing questions are related to the research and educational returns and benefits that local academics actually most value from various patterns of collaboration with Japanese companies. Further questions were raised to see if there are any distinctive features in working with Japanese companies and any notable differences compared to UK companies.

With such interests, the author conducted interviews with 8 key academics affiliated to the following UK top tier universities, namely 1*) University of Cambridge, 2) Imperial College*, *3) Bristol University*, *4) University College London*, *5) University of Durham*, *5) University of Oxford* and *6) University of Bristol*. All of the universities are involved with collaborative research funded by Japanese companies. The interviewees were all university professors working as in full-time positions with rich experience of working with industry.

These universities are known for their unique successes and are the most popular universities to be selected as partners by Japanese industry. The names of the interviewees appear in Table 4.1 as partnering Japanese companies are classified into technology intensive sectors such as consumer electronics and IT communication, pharmaceuticals, automobiles and chemicals. Seven from the list have been collaborating with Toshiba, Eisai, Nissan and Hitachi, whose responses to the survey distributed to 153 companies indicate a high satisfaction rate from the perspective of business and scientific values ( Figure 4.1).

Moreover, additional interviews were conducted with five key academics from the University of Cambridge who have been leading collaborations with UK flagship companies such as British Petroleum, Jaguar Land Rover, and multinational companies namely Unilever and Philips, to see whether any different features are perceived between UK and Japanese companies. These three companies are classified as the most proactive entities in terms of open innovation research with UK HEIs. Most interviews took about an hour to be completed. The main questions raised at an each interview are as follows:

1) ***What are the main incentives for your collaboration with industry? What benefits do you expect and actually most value from collaboration with partnering***

*companies?*

2) ***What are the research and educational impacts derived from such collaboration?***
3) ***What are the patterns of collaboration and how are the results and outputs evaluated?***
4) ***Are there sufficient levels of autonomy secured for researchers to decide research themes, thereby retaining academic freedom?***
5) ***How are the results of collaboration dealt with in terms of IP and conflict of interests with companies?***
6) ***Are there any barriers or challenges encountered? If so, how do you overcome them?***
7) ***Do you see any differences in terms of the pattern of collaboration and strategies between UK and Japanese companies? Any lessons learnt to improve knowledge exchange and sustainable collaboration?***

## 6.3 Summary of findings

### *6.3.1 Driving factors for U-B collaboration with Japanese companies*

- Dealing with complexities in new areas of research requires a multidisciplinary approach. U-B collaboration is essential in this respect, as it provides incentives for university researchers and especially young students, thereby widening their motivation to engage in more applied areas of research.

- Drivers for engagement by universities include income generation, employability for students, and bringing different perspectives to the research agenda. There are many different types of partnerships in place at present, whether based on research project, specific commissions, or student placements and broader engagement.

- Financial resources are not the most important reasons behind collaboration with Japanese companies. More importantly, successful collaborations rely on investments in time spent on joint work and the exchange of ideas, materials or tools.

### *6.3.2 Benefits driven by collaboration*

- Bilateral linkages led by UK academics and Japanese industry mean a lot and create opportunities to participate in multinational projects funded by the EU. The expected outcomes through collaboration with Japanese companies are synergies from such collaboration.

- Working with Japanese companies is significant in terms of research incentives and funding opportunities and, even more importantly, evidence of working with Japanese companies gives a certain credit and is highly valued by the department and university technology transfer office. The record of accumulated achievement through such collaboration offers great advantages that are essential to maintain and expand a researcher's own laboratory.

- Collaboration with Japanese companies induces a great impact on research productivity, stimulating incentives particularly for young researchers such as PhD candidates and post docs. Through closely working with companies, these students gain professionalism and certain skills to communicate with experts with different backgrounds and experience. They are encouraged to learn capacity building and to contribute their scientific outcomes to the emerging issues and needs of the whole of society.

### *6.3.3 Academic freedom to choose research themes*

- The research topics and ideas for projects in U-B collaborative activities are usually identified by a bottom-up discussion with the related sectors. Based upon proposals and suggestions related to research ideas, further discussion will be developed. The UK U-B system works quite well, although in a slightly different way to that in Japan.

"The main research theme defined by Hitachi by considering Cavendish's capabilities and strengths very carefully. One main annual meeting in Cambridge, senior members come to Cambridge present main results. There is a regular weekly team meeting to report the progress. He personally once a year has a chance to come to Japan. Hitachi HQ highly values scientific outputs. They have an increased number of accepted papers to the high quality journal over last five years, nature, science etc. I appreciates the Hitachi's flexible attitude that respect academic freedom and value the significance of fundamental research" (Prof E.

Sirringhaus, University of Cambridge).

“Unilever sends a few employees for one through three-month who work with academic here and take their ideas back to the company. They have three lecturers one of which spends a lot for undergraduate, carrying out workshop. Although Unilever funds infrastructure, other companies are allowed to access and use our facilities. Unilever gives freedom to academic here to do whatever research they want to conduct. It is very important for Cambridge professors to maintain academic freedom and equally importantly not to work with direct competitors of Unilever.”

“In the year 2000, BP endowed our institute with 24-million GBP investment. Since then BP institute has run for their own interests but allowing academic freedom without setting a short term, rather than that, it was ideally set for relatively long term around 10 year time span. In such a way, BP institute in Cambridge has a very different strategy among standardized patterns often employed as for industry-academic collaboration.”

### 6.3.4 *Featured patterns of collaboration*

- Most Japanese companies start trial collaborations with a one year contract, so it sometimes takes quite a while to engage in multiyear projects. In the early stages, they are less interested in expanding co-funding by matching the funds from British organisations, such as research councils, while UK academia suggests launching project-based collaboration.

- Japanese companies identify the most appropriate academic partners mostly by relying upon their own investigation through their networks. The approach is usually made directly by the Japanese side.

- Partnerships are formed on an individual basis, rather than as part of a broader "relationship with industry", each with different starting points and aims. As with international collaboration between academics, knowledge exchange often comes about through personal networks. The strongest partnerships take time to build smaller projects, which may be necessary before a relationship of trust is developed where the strongest work can be carried out.

*6.3.5 Differences between UK and Japanese companies*

- Most UK domestic companies, regardless of the size of their R&D expenditures and sales and number of employees, do not own their in-house R&D facilities, unlike Japanese companies. Thus, it is not unusual for open innovation in working with higher education institutes to happen more naturally, and university researchers need such collaboration to survive and to expand the size of their own laboratories. The conflicts of interest between the industrial and academic sectors appear to be a more serious issue in Japan compared to the situation in the UK.

- Japanese companies prefer to establish a personal link by sending a secondment to UK institutes. The primary aim of these Japanese companies is to gain an understanding of UK researchers' capabilities and skills in specific research areas. On the other hand, UK academics prefer to establish a long-term collaboration matched with their own funding resources available in the UK.

### *6.3.6 Challenges encountered for further collaboration*

- The overall picture of Japanese companies' global strategies is not very clear to UK academics. The critical decision-making is strictly centralised.

- The strength of ties and level of trust between each party in collaborative R&D is found to have a positive impact on information and knowledge transfer, which may generate spill over effects.

- Trust is an important issue, as scientists are often required to work on a "black box". However, cultural differences are not significant as scientists worldwide share a common culture.

- The development of an understanding of the institutional framework in which partner organisations operate is essential for sustainable collaboration. Building trust requires a shared vision of the objectives of the collaboration. It cannot be achieved without clarifying motivation and achieving transparency in decision-making.

**Table 4.1. List of interviews with academics working with the Japanese companies**

| Name of University | Partnering Japanese companies | Areas of collaboration | Pattern of collaboration | Other collaboration with non-Japanese companies |
|---|---|---|---|---|
| University of Cambridge | Toshiba, | Smart energy and infrastructure, computer vision | Contract research, Consulting, | UK, US, Germany, Netherlands |
| University of Cambridge | Toshiba, Toyota, IHI | Autonomous system, Advanced engineering | Contract research, Consulting | UK, US |
| University of Cambridge | Hitachi | Quantum, Nanoelectronics, Spintronics, | Joint research, Consulting | UK, Germany, |
| University of Durham | Sumitomo Chemical | Chemical, Organic electronics | Contract research, Consulting | UK, Germany |
| Imperial College | Ono Pharma, Asahi Kasei Pharma, Toray | Neuroscience | Consulting, Contract research, Accept secondment | UK, US, Germany |
| University of Oxford | Nissan | Information engineering | Consulting, Contract research, Accept secondment | UK, US |
| University College London | Eisai | Neuroscience, Diabetes | Consulting | UK |
| University of Bristol | Toshiba, Fujitsu, Kyocera | Wireless technologies | Joint research, Contract research, Consulting | UK, Germany, US |

(Source: Author)

**Table 4.2. List of interviews with academics working with UK companies**

| Name of University | Partnering companies | Areas of collaboration | Pattern of Collaboration | Any collaboration including Japanese companies |
|---|---|---|---|---|
| University of Cambridge | Unilever | Chemical | Contract, Consulting, Researcher exchanges | No |
| University of Cambridge | British Petroleum (BP) | Chemical | Contract, Consulting | Yes |

| | | | | |
|---|---|---|---|---|
| University of Cambridge | Jaguar Land Rover | Advanced electronics, Photonics | Collaborative research, Contract, Researcher exchanges | No |
| Imperial College | GlaxoSmith-Kline | Medical devices | Consulting, Contract research | No |
| University of Oxford | GlaxoSmith-Kline | Target Validation | Contract research | Yes |

(Source: Author)

**Table 4.3. UK-Japan Symposium: Building International University-Business links co-hosted by British Embassy and British Council, Tokyo, January 10-11 2012**

- **List of Participants from Japanese Organisations**

| Organisation | Name | Position |
|---|---|---|
| Council for Science and Technology Policy, Cabinet Office (CSTP) | Prof Masuo Aizawa | Executive member |
| Japan Science and Technology Agency (JST) | Dr Michiharu Nakamura | President |
| Ministry of Education, Culture, Sports, Science and Technology (MEXT) | Mr Atsushi Hashizume | Director, Office of University Technology Transfer |
| Ministry of Education, Culture, Sports, Science and Technology (MEXT) | Mr Itaru Watanabe | Senior Deputy Director-General Science and Technology Policy Bureau |
| Ministry of Economy, Trade and Industry (METI) | Mr Hideo Shindo | Director of Academia and Industry Cooperation |
| University of Tokyo | Prof Tomonari Yashiro | Director General, Institute of Industrial Science |
| Keio University | Prof Koichi Hishida | Director General, Headquarters for Research Coordination and Administration<br>Professor, Department of System Design Engineering |
| University of Tokyo | Prof Robert Kneller | Research Center for Advanced Science & Technology |
| Kyoto University | Prof Keisuke Makino | Vice President, Director of Office of Society-Academia Collaboration for Innovation |
| Keio University | Prof Toshihisa Ueda | Director of Keio Leading Edge |

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|---|---|---|
| | | Laboratory of Science and Technology |
| Toyoda Gosei., Ltd. | Mr Koichi Ota | Corporate Auditor, Board of Corporate Auditors |
| Tohoku University | Prof Toshio Miyata | Director, United Centers for Advanced Research and Translational Medicine (ART), Tohoku University Graduate School of Medicine |
| Tokyo University of Agriculture and Technology | Prof Koji Sode | Director, Center for Innovation and Intellectual Property/Graduate School of Engineering |
| Nagoya University | Prof Yukio Ishida | Graduate School of Engineering, Department of Mechanical Science |
| Waseda University | Prof Toru Asahi | Faculty of Science and Engineering/Executive Director of Doctoral Student Center |
| Toshiba Corporation | Dr Yutaka Sata | Group Manager, Planning and Coordination Group |
| GVIN Ltd. | Dr Yutaka Kuwahara | President & CEO |
| Mitsubishi Heavy Industries | Mr Kan Ogata | Deputy chief researcher, Technology Planning Department Technology & Innovation Headquarters |

**Table 4.4. List of Participants from UK Organisations**

| Organisation | Name | Position |
|---|---|---|
| Higher Education Funding Council for England（HEFCE） | Ms Alice Frost | Head of Business & Community Team (Research, Innovation and Skills) |
| British Embassy Tokyo | Mr Kevin Knappett | Head of Science and Innovation |
| GlaxoSmithKline (GSK) | Dr Malcom Skingle | Director Academic Liaison |
| University of Bristol | Prof Eric Thomas | Vice-Chancellor of University of Bristol/President of Universities UK |
| University of Liverpool | Prof Stephen Holloway | Executive Pro Vice Chancellor, University of Liverpool |
| University of Southampton | Prof Mark Spearing | Pro Vice Chancellor (International), University of Southampton |
| University of Warwick | Mr Quentin Compton-Bishop | CEO, Warwick Ventures Ltd. |
| Astellas Pharma | Dr Ichiro Aramori | Executive Fellow, Research Management |
| Newcastle University | Prof Ella Ritchie | Deputy Vice-Chancellor |

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|---|---|---|
| University of Leeds | Prof Judith Lamie | International Director |
| 2Bio Ltd | Dr Geoff Wainwright | Director |
| Oxford Instruments | Mr Tony Ford | Director |
| Rolls Royce Japan | Mr Nozomi Takei | Vice President, Business Development |

(Source: Author)

## Appendix 3.

**List of Interviews with Academics and Business Representatives involved with U-B collaboration**

- **26 Interviews in UK**

| **Name** | **Position** | **Organisation** |
|---|---|---|
| **Company** | | |
| 1.Dr David William | Director, Chief Research Scientist and Laboratory Manager | Hitachi Cambridge |
| 2.Prof Joe McGeehan | Managing Director | Toshiba Research Europe |
| 3.Dr Shuichi Uchikoga | Deputy Director | Toshiba Cambridge |
| 4.Dr Ian Thompson | Head of Laboratory | Sharp Oxford Laboratory |
| 5.Dr Takayuki Yuasa | Vice President | Sharp Oxford Laboratory |
| 6.Mr Shinpei Toh | Technology Management Officer | Sharp Oxford Laboratory |
| 7.Mr Ryuichi Taira | Director | Harada Industry UK |
| 8.Dr Andrew Ayscough | Director of Chemistry | Takeda Cambridge |
| 9.Mr Yousuke Matsuno | Senior researcher | Nissan Motor |
| 10.Dr Ryuta Tsuchiya | Deputy Manager | Hitachi Europe R&D Centre |
| 11.Dr Sybo Dijkstra | Senior Director | Philips Cambridge R&D |
| **Science Park** | | |
| 12.Mr Richard Wheeler | Head of Business Development | Kent Science Park |
| 13.Mr Ian | | Oxford Science Park |
| 14.Mr Paul Wright | CEO | UK Science Park Association |
| **University** | | |
| 16.Prof Henning Sirringhaus | Hitachi Professor of Electron Device Physics | University of Cambridge |
| 17.Prof Kenichi Soga | Professor of Civil Engineering | Department of Engineering University of Cambridge |
| 18.Prof Bill Milne | Director | Centre for Advanced Photonics and Electronics (CAPE) University of Cambridge |
| 19.Dr Tim Minshall | Senior Fellow | Institute of Manufacturing, University of Cambridge |
| 20.Prof Paul Michael Newman | BP Professor of Information Engineering | Department of Engineering Science, University of Oxford |
| 21.Dr Stuart Clarke | Fellow of Jesus College | BP Institute, University of |

| | | |
|---|---|---|
| | | Cambridge |
| 22.Dr Dean Willis | Senior lecturer | Neuroscience Physiology & Pharmacology, University College London |
| 23.Prof Kenji Okuse | Senior lecturer | Department of Life Sciences, Faculty of Natural Sciences, Imperial College |
| 24.Prof Robert Glen | Director, Unilever Professor of Molecular Sciences Information and Director of the Centre for Molecular Sciences Information | Unilever Centre, University of Cambridge |
| 25.Dr Koichi Matsuda | Research fellow | Department of Engineering, University of Cambridge |
| 26,Dr Steve Cleverley | Managing Consultant | ISIS innovation, University of Oxford |

- **25 Interviews in Japan**

| Name | Position | Organisation |
|---|---|---|
| 1.Dr Takemitsu Kunio | Associate Senior Vice President, Executive General Manager, CRL | NEC |
| 2.Mr Hiroshi Katayama | Vice President, CRL | NEC |
| 3.Dr. Toru Takeda | General Manager, Technology Strategy Dept | Sony |
| 4.Mr. Koji Kumano, | Global R&D Manager, Section 1, Technology Strategy Dept | Sony |
| 5.Dr Shoichi Miyata | Assistant General Manager, Management Planning Board | Sharp |
| 6.Mr Hiroshi Hayashi | Division Deputy, Division Deputy General Manager, Advanced Energy Technology Laboratories | Sharp |
| 7.Dr Hiroshi Ohji | Manager, Planning & Administration Dept, Corporate Research & Development | Mitsubishi Electric |
| 8.Mr Toshio Idei | Manager, Planning & Administration Dept, Corporate Research & Development | Mitsubishi Electric |
| 9.Dr Noboru Yamamoto | Eisai Product Creation Systems | Eisai |
| 10.Dr Fumiyoshi Matsuura | Eisai Product Creation Systems | Eisai |
| 11.Dr Akira Hasegawa | Research Associate, Tsukuba Research Laboratory | Sumitomo Chemical |
| 12.Dr Daikou Tei | President & Chief Executive | Santec |
| 13.Mr Koshi Sakamoto | General Manager, Business Development & Licensing | Asahi Kasei Pharma |
| 14.Dr Kohei Ogawa | General Manager, Pharmaceutical Business Administration Division | Asahi Kasei Pharma |
| 15.Dr Hideaki Koizumi | Hitachi Fellow, Corporate Officer Hitachi, Ltd. | Hitachi |

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|---|---|---|
| 16.Dr Masashi Kiguchi | Senior Research Scientist, Unit Leader, Bio and Management Systems Laboratory | Hitachi |
| 17.Dr Yutaka Yamashita | Manager, The 7th Research Group, Central Research Laboratory, Hamamatsu Photonics | Hamamatsu Photonics |
| 18.Dr Tadahiko Shimazu | Senior General Manager, Finance Division, International Division | Hamamatsu Photonics |
| 19.Dr Satoru Kohno | Senior Engineer, Senior R&D Manager, Shimadzu Corporation | Shimadzu Corporation |
| 20.Dr Shohachi Nakajima | Director, Takasaki Plant, Production Division | Kyowa Hakko Kirin |
| 21.Dr Yutka Sata | Group Manager, Planning and Coordination Group, Technology Planning Division | Toshiba |

| **University** | | |
|---|---|---|
| 22.Prof Andrew Monkman | University of Durham, | University of Durham |
| 23.Dr Philip Guilford | Director of Research, Department of Engineering | University of Cambridge |
| 24.Prof Paul Matthew | Imperial College | Imperial College |
| 25.Dr Robert Leese | Director | Smith Institute for Industrial Mathematics and System Engineering |

# CHAPTER SEVEN

## Conclusion

An increasing number of Japanese companies have established R&D centres in the UK, thereby maintaining and intensifying collaboration with local HEIs. The R&D centres of Japanese companies are concentrated in east and southeast England, regions well-known as innovation hot spots where many prestigious universities and global companies are based. The most proactive sectors are consumer electronics and ICT, which, in the early 1990s, became the first inward investors in the UK. Two giant Japanese electronics companies, Sharp and Toshiba, decided to move into the Oxford and Cambridge science parks and established the first overseas corporate-level R&D laboratories about 20 years ago. More recently, over the last decade Japanese pharmaceutical companies, including Takeda in the Cambridge Science Park, Eisai, and Shionogi have become keen to launch new collaborative schemes and explore new university partnerships through their R&D strategies and visions of open innovation.

This study provides us with a rich understanding of the open innovation system of global firms involved with collaborative R&D linked with local higher education institutes abroad. In response to the significant issue of how global companies fit within R&D strategies and the host innovation system, it is designed to look into the different patterns of collaboration and advantages for those companies to be based at an innovation hot spot in the UK.

The results of the questionnaire distributed to 153 Japanese companies in the UK find that companies choose a location that comports with their R&D global strategies. Specifically, the 23 Japanese companies identified as the most proactive in working with local universities are classified into three categories based on their locations in order of geographical closeness, 1) on campuses, 2) in science parks and 3) at independent sites. It is clearly shown that geographical differences reflect the pattern of their activities and their levels of satisfaction.

Principal component analysis (PCA) demonstrated that companies in UK science parks and university campuses showed higher levels of satisfaction, with advanced research outputs and business benefits, compared to those at independent sites. The geographical proximity to HEI has a positive impact on the organisational capacity of Japanese companies by enabling them to embed in local innovation networks and utilise the advantages of the excellent research environments in science parks and campuses. Japanese companies located in regions where higher education institutes are concentrated are more likely to be innovative than companies located elsewhere due to the benefits they gain from the knowledge that emerges from these academic sources.

In contrast to the conventional views emphasising the limited internationalization of Japanese corporate R&D in abroad, Japanese companies in UK who marked high satisfaction rate in questionnaire are good at choosing the strategic local partners who have rich experience in working with industry. Relied on the local partners' experience and knowledge are critical for the company to explore the future course of research collaboration and obtain new opportunities to join UK national projects.

Moreover, those companies successfully gained advantages and privileges in terms of extensive dialogue with science communities in other European countries, these companies have been deeply involved in EU projects, which serve as a hub in the European research network. Also most companies perceive highly qualified human resources as well as new knowledge and ideas as essential for future products based in the UK. In terms of the pattern of actual collaborative activities, the majority of companies undertake informal contact with academics and sponsor research trials or projects.

The literature on Metanational management states it is crucial that companies recognize and acquire emerging technologies, skills and market needs as quickly as possible and transfer theses with the aim of creating the innovative products, services and production processes they will utilize in their daily operations. As exemplified by the changed strategies employed by Japanese giant electronics companies like Toshiba and Hitachi, they attempt to spot market needs and knowledge from abroad to build their competitiveness. They set up top priority on absorbing external resources by utilizing their alliances in order to build competitive advantages on a global scale instead of relying solely on securing advantages in a business' home country.

The author conducted interviews with senior managers from companies with high satisfaction rates, namely Toshiba, Hitachi, and Sharp. Common features are their efforts to build strong personal networks with local academia and funding agencies. By relying on the advantages of geographical proximity, they easily access highly qualified facilities and human resources. After securing targeted experts from HEI with sound records of scientific research and rich experience working with industry, these companies continue to recruit young local researchers and localise their patterns of knowledge management.

For Japanese subsidiaries in the UK, it is assumed that mutual concerns over the maintenance of reputation in the local setting can induce different actors with common backgrounds to quickly form bonds. Trust can help to mitigate the problems of opportunism and lower the costs of writing contracts for knowledge sharing. This may be especially important in the context of university–business collaboration where different norms and incentives often lead to clashes and disputes over the direction of research and the timing of disclosure of research findings.

Dealing with complexities in new areas of research requires a multidisciplinary approach. University-business collaboration is essential in this respect, as it provides incentives for university researchers and especially young students, while widening their motivation to engage in more applied areas of research. The strength of ties and the level of trust between each party in collaborative R&D is found to have a positive impact on information and knowledge transfer, which may generate spill over effects.

As highlighted in the interviews with senior professors working with Japanese ICT, automobile, and pharmaceutical companies, the Japanese companies have strong personal links with UK academia and gain some advantages and privileges in terms of human resources, excellent facilities and related business support. These companies have successfully explored a wider research network through strong personal links and other related research funding agencies as well as the scientific community. It can be summarised that some degree of personal contact or oral communication is necessary for knowledge to be effectively transferred. Moreover, most interviewees were involved with EU projects, which serve as a hub in the European research network.

Throughout the interviews, it was frequently pointed out that the expected outcomes from collaboration with Japanese companies are synergies from multinational collaboration, so UK entities prefer more strategic involvement with a long-term vision. Working with Japanese companies is important not merely for research incentives and funding opportunities but also for political purposes, which are very important. There has been a significant transition, both within UK and Japanese universities, from technology transfer to strategic relationships, as technology transfer through licensing and spin out companies has not been that successful as either a generator of income or as the most efficient method of technology transfer.

The above interview results would affect new policy instruments for the government that should not be too narrowly focused on policy incentives to develop commercial values; rather, policymakers should explore new institutional arrangements capable of achieving a variety of interpersonal and organisational exchanges that can inform and feed back into teaching, research and problem solving interactions.

The findings from this study can help managers at global companies that engage in technology-intensive R&D who are keen to internationalise their R&D strategies in order to access an excellent knowledge base. The experts directly involved with human resources and organisational management will value the outcomes of this research as providing good models for future decision-making and, in the process, of improving returns over cost and the capabilities of skilled workers. Moreover, the UK government perceives the increased inward investment from foreign countries as a catalyst for creating new jobs and for economic growth, as well as promoting knowledge-based innovation. In this sense, this study highlights the need for further institutional arrangements to attract foreign companies and efforts to capitalise on foreign-hosted firms.

As demonstrated by the relatively high satisfaction rate of Japanese companies located in science parks, well-managed science parks are expected to bring about spill over effects among local tenant companies. However, only a modest level of interaction between Japanese and local companies has been observed. In this sense, local governments play a significant role in helping improve the local institutional environment for innovation in that various networking organisations provide forums to bring business people, academics, technologists and service providers together. Towards that end, a range of intermediary organisations are essential, including the innovation centre and entrepreneur networks on the commercialisation of technology and vigorous regional development.

Although the developmental process of science parks in the UK and Japan is quite different, science parks in both countries share the same interests with regard to further commercialisation and innovation. The Cambridge phenomenon, characterised by its robust regional cluster, is underpinned by the so-called “collective learning process” that facilitates the new technological and managerial knowledge flow between various actors, such as firms and institutions. It is strongly suggested that the strategies governments use to promote innovative technology clusters should be carefully adapted to the particular historic, social and spatial environment of a specific region. Successful technology clusters need to be built upon existing strengths, especially strengths and advantages related to university research and scientific excellence. Core research institutes and universities should adopt a liberal and reliable regulatory attitude with regard to the commercialisation of the research and knowledge generated by their staff, faculty and researchers. Well-managed intellectual property rights would provide a fertile environment for firm spin-offs and technology transfer.

As for the limitations of this study, it did not fully demonstrate the impact of the collaboration of Japanese companies’ R&D with UK HEIs on local regional innovation. Given that UK universities with excellent research bases have been successfully attracting foreign technology-intensive companies, an intriguing issue is how a host innovation system can capitalise on foreign-hosted firms. This effect warrants a comparative study of other proactive investors in the United States and other European countries. By investigating details of ongoing collaborations led by global companies with different nationalities, future studies should clarify the policy incentives that are necessary for the host country to improve performance and promote regional innovation derived from internationalised university-industry collaborations.

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