1 Introduction

In terms of the knowledge management and firm competencies debate, acquisition of external knowledge through collaboration requires the ability of a firm to extract value from these relationships, not least in the transfer of knowledge to the internal innovation activities of the firm. At the same time, firms must possess the capabilities to manage internal and external innovation processes in a complementary way to ensure that external technological knowledge acquisition supports internal activities and does not undermine them in any way.

This paper will report a number of experiences from three UK-based firms engaged in our recent study into decision-making processes surrounding the external sourcing of technological knowledge into firms. These three firms (including the lead coordinator – BAE Systems) were part of a seven-company collaborative research project that was part funded by a UK government sponsored aircraft industry research programme. This project consortium was researching and developing advanced technologies for automatic wing box assembly for large aircraft like for example, the Airbus A380. Here we need to note that in the mainly labour-intensive civil aircraft industry, automated manufacturing has gained credibility in some areas as production volumes have increased. The consortium project described in this case study provides an example of leading-edge manufacturing technologies being examined by Airbus Industries to help meet delivery
schedules as orders grow and to facilitate manufacture of more sophisticated wing designs.

2 Brief theoretical background

A growing stream of research in the fields of strategic management and organisational science exploring strategic alliances has been described as vast and increasingly important [1,2]. Technology management research has also identified lists of motives for these types of alliance formations and some of these alliances are described as research and development partnerships or collaborations [3,4]. The typical motivations usually identified include market entry, changes in market structure, resource efficiency, resource acquisition, and skill enhancement [5]. Stuart [6] also observes that while explanations of collaboration formation are directly linked to the presumed benefits of such arrangements, surprisingly few studies have explored the conditions under which collaborative alliances prove advantageous. Ingham and Mothe [7] contend that the nature of the relationships a firm maintains among its network partnership should be conditioned on both the structure of the overall network consortium and the ability of a firm to effectively absorb external knowledge via the collaborative research project partnership.

The literature indicates that there are many potential knowledge advantages associated with collaborative partnerships [8,9]. Sometimes some knowledge may be obtained in no other way than through partnering with a firm that has control over an important technology [10]. Thus, there is great potential value associated with pursuing a knowledge accumulation and creation strategy through collaborative partnerships. Often the decision-making criteria of the firm revolve around whether to use collaborative partnerships to gain knowledge and/or an assessment of the costs associated with potential knowledge gains and losses [11]. The increasing complexity and interdisciplinary nature of the R&D process has increased the cost of research [12]. Research may therefore become less attractive without partners to share the cost. More simply the firm may lack the financial resources to undertake research even if it remains an attractive proposition [13,14]. Associated with this, the traditional barriers between scientific and technical disciplines are being broken down, as the interchange between basic research and development grows. This pressure to improve the interface between basic research on the one hand and applied and developmental work on the other also stems from the pressure to reduce innovation cycle times.

3 Key empirical research company findings

This section draws on empirical research findings from observing the experiences of some UK-based companies engaged in our study. This study analysed the decision-making criteria of a number of firms for the effective management of company decisions regarding the use of in-house knowledge generation versus external knowledge acquisition and outsourcing, through the development of a Decision Support Framework model [15].

Here we specifically report on findings from three companies: BAE Systems (Broughton), AMTRI (Macclesfield) and RTS Robotics (Irlam). When BAE Systems began to build large civil aircraft in increasing volumes, a review of their production and assembly operations found them to be labour intensive and required automation of Wing
Box Assembly, previously a manual shop floor process to speed up production. The need to automate shop floor operations in wing box assembly saw the company seek appropriate expertise for this type of automation technique, outside the company and industry. Rather than choosing to develop this technology within their corporate laboratories in the UK (Sowerby Research Centre), BAE Systems chose a collaborative approach as a means of gaining the appropriate knowledge and expertise from other industrial sectors such as the automotive sector.

BAE Systems approached the UK government for collaborators and part funding (in region of £5 million pounds) under the government’s CARAD Programme (also later known as the Aeronautics Research Programme). This resulted in an alliance between BAE Systems (project management and provision of facilities and materials, plus at their Sowerby Research centre – vision and sensor automated positioning systems) and AEA Technology (robotic fastening and process control), AMTRI (automated handling and positioning systems), Technomatix (software and simulation packages specialist), Lieca (measuring systems expert) and RTS Robotics (robotics systems). The aim of this national funding programme was to maximise technology transfer to civil aircraft from other sectors and areas including materials, electronics and design techniques. This programme supported pre-competitive collaborative ventures that carry high technical and financial risk, with the aim of reducing the barriers to collaboration and increasing market access. This section presents key findings from the three firms interviewed (Note: these specific findings could only be disclosed in public domain after from 2008 onwards due to commercial confidentiality issues arising):

**BAE Systems**

Although BAE Systems was the main instigator of this project, it is apparent that the other organisations collaborating in this project also had their own perspectives and decisions that influenced their involvement in this collaborative partnership. At BAE Systems the main criteria for this technological collaboration was that BAE required more in-depth knowledge of automation techniques, which although already held within the company, was required in order to learn from other sectors and industries plus acquire ‘state of the art’ technological expertise to develop this technology further. From an R&D management perspective, BAE believed that they were acquiring useful technical knowledge through working with other consortium partners on this particular project. Here it was pointed out that although BAE staff were generally well aware of a number of key developments in the areas of ‘automatic handling and positioning’ technology, they did not possess the depth of expertise regarding what is currently considered to be ‘state of the art’ technology around the world in this particular area of technological expertise.

An interesting insight into the decision-making criteria of entering into this collaborative partnership is provided, since BAE felt that at the project commencement stage this was not a collaborative partnership in the true sense of partnerships. BAE had identified some end goals that they would like to have achieved at the end of this project. However it was unclear at the beginning how they would actually get to achieve their end goals. Therefore it had taken about eight months of the project for BAE and their partners to fully understand what was exactly required in terms of detailed design specifications and technical performance parameters. So the first phase of the project was considered to be a conceptual phase where the partner firms worked together on technical areas to come to a ‘common understanding’. There is generally a common acknowledgement amongst the companies interviewed here and others about the importance of robust decisions on the
acquisition of external technological knowledge. Nevertheless it is accepted that in reality the nature of this type of decision-making process is usually ad hoc. The companies were well aware of the need to develop a more sophisticated and intelligent approach to what they regard as an increasingly critical issue in knowledge management. BAE indicated that these types of decisions are often based on an incomplete information base not least because individual managers within large multi-business companies often struggle to know what their own colleagues know, let alone assess the multiplicity of formal and often more importantly, informal relationships that exist between organisation members and others. At the same time, there are practical constraints on the resources that can be devoted to the decision making process.

**AMTRI**

AMTRI is a small firm based in the North West of England that had already possessed solid experience of working in collaborative projects before they had entered as a collaborating partner on this project. The technical knowledge acquired through working on this project has helped AMTRI to develop some of this knowledge further in other parts of their business activities. For example, the knowledge acquired here was especially useful to other sector applications for AMTRI that included lorry trailer and railway coach applications that also involved the similar movement of large-scale panels and their positioning applications.

For AMTRI it was vital that they had the opportunity to sell their technical ideas and expertise to the manufacturing directors and manufacturing engineers inside BAE Systems, as they believed that it was the BAE manufacturing function that would give the ultimate go ahead for this technology to be used in a future full scale production environment. Therefore it was vital for AMTRI to demonstrate their technical expertise and reliability as a consortium partner organisation for any future commercial spin-offs from this research project. AMTRI had attempted to build their reputation on possessing the capability to offer customers’ excellent engineering ideas and concepts, but they strike a fine balance between telling the customer enough and telling the customer too much. This is seen as a classic knowledge management problem for knowledge-based firms of how you deal with customers and build mutual trust. Hence acquiring knowledge from this project was seen as a way of how effectively AMTRI could then internalise this knowledge and use it as a strategic tool for building future collaborative business opportunities.

**RTS Robotics**

RTS Robotics is also a small firm based in the North West of England and it is one of the UK’s foremost suppliers of advanced robotics and 3-D control laser and model building services to industry. The company specialises in supplying remote systems to a variety of markets including aerospace, nuclear, defence and automobiles. For this collaboration project RTS Robotics supplied an ‘internal robot’ for the AWBA demonstrator wing, which is an accurate system used for fastening *skin wrapping structures* in aircraft wing assembling operations. RTS had to work closely with BAE Systems and AMTRI, as well as collaborating with other project consortium partners. RTS Robotics had originally been approached by BAE Systems and other partners to join this consortium through the company’s links to the British Robotics Association.

The main strategic drivers for RTS, in deciding to join this consortium were that they were themselves confident that RTS possessed technical capabilities (in areas of
advanced robotics) to offer to the consortium, as these skills were developed mainly outside of the aerospace industry. An integral part of RTS business strategy was to actively search for collaboration opportunities with other firms since RTS senior management believed that their company lacked some credibility in having the ability to work on large-scale systems building projects of this nature. Therefore this collaboration project was seen as an important opportunity to improve credibility of the company in the industry. The project also enabled RTS to acquire a greater understanding of the industry needs in the civil aviation sector. Communication was seen as a key attribute of this consortium project. RTS reported that communication channels with the rest of the partners were very good and open-ended, which helped with smooth information flows. One of the only drawbacks reported by RTS was that due to their limited budget this did not provide them with the right financial resources to explore a range of different technological options as part of this project, as the lead partner, BAE Systems wanted RTS to generate a range of different options. So RTS could only work within the confines of their contracted budget and had little flexibility to explore some other interesting options, which in the longer run might have been strategically important for RTS.

4 Collaborative research project: knowledge acquisition issues arising

Having presented a number of empirical research insights, which highlight the key motivations for the firms studied to participate in the CARAD project collaboration, this section presents some important knowledge acquisition implications arising from the interviews conducted.

The CARAD project described in this paper is often referred to as a ‘research consortia’ in the literature. This is a partnership of a number of organisations working together on a relatively well-specified project [11]. The rationale for joining a research consortium includes sharing the cost and risk of research, pooling scarce expertise and equipment, performing pre-competitive research and setting of standards. Although all of this rationale for joining a research consortium has been confirmed within the CARAD project study, a number of other components could be added to this rationale. For example, seeking appropriate expertise for the automation of wing assembly on large civil aircraft from other companies outside of the aerospace industry like automotives. Therefore there was an emphasis on learning from state-of-the-art ‘handling and movement of large structures’ types of technology used in other sectors.

On a similar theme of acquiring knowledge from other industries, AMTRI wanted to acquire technical knowledge from the aerospace industry, which they might then subsequently be in a position to deploy in other research projects for road and rail transportation type systems. In essence this is a collaboration motivation to change their market structure and improve skills enhancement as described by Varadarajan and Cunningham [5] earlier in the paper. Also as confirmed by Tidd and Trehella [16], the increasingly interdisciplinary nature of many technologies and products mean that firms like the ones described in this paper, are seeking to leverage their in-house capabilities with those available externally via collaborative projects. As mentioned in the theoretical background section earlier, the increasing complexity of interdisciplinary research has increased the cost of research [12], whereby the sharing of costs and risks was one key motivation to collaborate for all partners in this consortium.
Business commentators often remark that many small entrepreneurial firms which generate new, commercially valuable technology fail while large multinational firms, often with a less meritorious record with respect to innovation, survive and prosper [17]. One set of reasons for this phenomenon is now perhaps more clear from this research study. Large firms (like for example, BAE Systems) are more likely to possess the relevant specialised assets within their boundaries during the early R&D project phase and they can to some extent do a better job of ‘milking their technology’ to maximum advantage. Smaller firms (like for example, RTS Robotics and AMTRI) are less likely to have the relevant specialised assets within their boundaries and so will either have to incur the expense of trying to build them, or of trying to initiate collaborations with other partners of the specialised assets. Connected to this issue is the fact that firms should have the inherent skills and resources necessary to absorb the acquired technological knowledge resulting from a collaborative research project, once the project is under way. Absorptive capacity appears to be positively related to such characteristics as the size of the firm, its marketing skills, and its production expertise [18]. Another definition of ‘absorptive capacity’ appropriate here is provided by Matusik [19], which is the ability to exploit external knowledge through the recognition of the value of new information, and the ability to assimilate and apply it to commercial ends. To effectively absorb knowledge from outside its boundaries, a firm must have enough related knowledge to recognise the value of new information, absorb the relevant information, and then use that information. Hence acquiring knowledge from this CARAD project for AMTRI was seen as a way of how effectively they could then internalise this knowledge and use it as a strategic tool for building future collaborative business opportunities.

Creating ‘trust’ is seen as probably the most important ingredient of success and a major reason for failure if it is absent. Trust can be competence based in the sense that each partner is confident that the other has the resources and capabilities to fulfil their part of the alliance [20]. This may include capabilities in business processes such as decision-making and motivation of staff as well as “technical” operational capabilities. Trust is also character based and can concern whether partners trust each other’s motives and are compatible in terms of attitudes to integrity, openness, discretion and consistency of behaviour [21]. This ‘trust’ aspect of the CARAD project relationship is well demonstrated in this research study. As mentioned in the last section, eight months of the project had elapsed by the time BAE Systems believed they had developed a ‘common understanding’ and began to recognise AMTRI and RTS Robotics and the other consortium partners as ‘partners’ in the true sense of a ‘partnership’, rather than as companies acting in a contract research organisation capacity. This point is also well demonstrated by Kelly et al. [22], who argue that the initial stages of a research collaboration should be used as an opportunity to learn about the partner(s), to develop effective communications and create a positive working atmosphere within the alliance partnership.

5 Conclusions

Consortium collaborations have become widespread in technology-intensive industries such as semiconductors, computers, software and commercial aircraft in which they were of little or no importance before the mid-1970s. In addition, the activities included in many of these collaborations, such as joint R&D and product development, often involve
relatively high levels of knowledge exchange and technology transfer amongst participants. Also the increasing complexity and inter-disciplinary nature of the R&D process has increased the cost of research. Research may therefore become less attractive without partners to share the cost.

We have noted that while the SME firms studied have stability in their top management team, the large firm may suffer from periodical reorganisations and job rotations, in particular at the operational levels. A new management team may not understand the logic of a partnership or share the same level of commitment as the previous team had. In order to cope with this type of situation, the SMEs must ensure that they get the commitment from the top of the large organisation, which was demonstrated in this case study by AMTRI and RTS, who made special efforts to build this relationship with the BAE manufacturing department management hierarchy. Also for the SMEs, the access to complementary assets is an important objective, but the overall goal should be one of constant learning and absorption of know-how and to ensure that adequate resources are committed to achieving this goal. A range of factors can influence a firm’s choice of partnering approach, including the company’s strategy and existing technological capabilities as well as ‘softer’ factors such as the firm’s culture and the ‘comfort’ of its management with a given technological area. The character of the technology in question can also be important, including its competitive impact, complexity and codifiability. Organisations often have to go through a period of trial and error learning in order to understand how to effectively acquire knowledge from an external source. Sometimes this requires extensive effort and time to build up an understanding of the norms, habits, and routines of different external partners. This process of learning to absorb external knowledge is subject to considerable uncertainty in the sense that \textit{ex ante} it is difficult for managers to know which external source will be the most rewarding before engaging in the relationship [23].

Finally, the paper has identified some of the factors that appear to lead to successful collaborative partnerships. The development of the necessary absorptive capacity to transfer knowledge and learn from the partnership was emphasised as critical. Equally, the success of an alliance tends to be dependent on how it is managed and the way in which the participants foster the evolution of the partnership. Ultimately, there is a widespread recognition within the academic and practitioner literature of the importance of relationship building and the cultural dimension to alliance effectiveness.

References


