Agile manufacturing and technology transfer to industrialising countries

Harm-Jan Steenhuis *
Department of Management, College of Business and Public Administration, Eastern Washington University, 668 N. Riverpoint Blvd., Spokane, WA 99202, USA
E-mail: harm-jan.steenhuis@mail.ewu.edu
*Corresponding author

Sirp de Boer
Technology and Development Group, University of Twente, PO Box 217, 7500 AE Enschede, the Netherlands
E-mail: s.j.debor@tdg.utwente.nl

Abstract: One of the requirements of agile manufacturing, the necessity to gain flexibility, can be reached by using a supplier network. A possible way to develop a supplier network is by subcontracting to parties in industrialising countries. In most cases it is necessary to transfer technology. The aircraft industry is an industry in which such technology transfer frequently takes place. This research project examined the process and consequences of technology transfer in the field of manufacturing. Four case studies were carried out in the aircraft industry. The case studies showed that there are two types of technology transfer: technology selling and technology sharing. Technology sharing frequently takes place in the aircraft industry. The results indicate that ‘Destination Companies’ hardly benefited technologically from technology sharing because the Destination Company is selected for its existing capabilities. In addition, it is questionable whether production technology transfer contributes to economic growth for industrially developing countries. ‘Source Companies’ that want to work towards agile manufacturing have limited options for technology transfer towards industrially developing countries due to the requirements placed upon the capabilities of the Destination Company and the infrastructure requirements for countries.

Keywords: International technology transfer; economic development; aircraft industry; agile manufacturing.


Biographical notes: Harm-Jan Steenhuis is an assistant professor at the College of Business and Public Administration, Eastern Washington University. He received an MSc in Industrial Engineering and Management and a PhD in International Technology Transfer from the University of Twente, the Netherlands. He is currently involved in research on R&D-level technology transfer in industry-university cooperative research and in research on international production issues.
1 Introduction

Companies in industrially developed countries expand their operations into industrially developing countries for a variety of reasons and in different forms. One reason could be to increase the agility of the company. "Agility is the ability of a manufacturing system to manufacture a variety of components at low cost and in a short period of time. The agile manufacturing system should be simple, flexible, reconfigurable, reliable, responsive to market changes, and so on" [1]. Flexibility is thus one of the issues of agility. Narasimhan and Das [2] examined the role of supply chain management practices in achieving operational flexibility. They identified three types of flexibility to increase operational flexibility: volume flexibility, modification flexibility, and delivery flexibility. During the creation of a supplier network technology is transferred from the customer to the supplier in order to increase the flexibility of the customer.

This research on international transfer of technology gives insight into where technologies are likely to be transferred within these networks and what benefits result for the Source Companies (SC, the company where the technology originated) and the Destination Companies (DC, the company that receives the technology).

2 Methods

The research project was set up to investigate, in detail, the process of technology transfer. Understanding the technology was considered to be of prime importance, hence the field study involved one technology: aircraft production. Four case studies were executed in accordance with Eisenhardt [3]. The case study selection was based on theoretical sampling and in addition, insights gained in earlier case studies were used to identify later potential cases (snowball sampling, see [4,5]). The research was carried out at the DC because this is where the implementation takes place. During nine months in DCs, approximately 315 interviews were held with 45 different people representing both SCs and DCs. To overcome some objections against case study research, notably that the number of variables is larger than the number of cases [6], several strategies were followed to increase the degrees of freedom of the data. These strategies included: triangulation, member check, and collecting data from other companies for comparison.

In total four case studies were carried out, the selection of which was done in accordance with the variables in Table 1.
Table 1  Case characteristics (case and company names have been altered for confidentiality reasons)

<table>
<thead>
<tr>
<th>Case</th>
<th>Age of technology</th>
<th>Magnitude of technology</th>
<th>Source company and country</th>
<th>Destination company and country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woodpecker (entire aircraft)</td>
<td>approximately 10 years</td>
<td>large</td>
<td>Birds of the Woods (UK)</td>
<td>Mountain Birds (Romania)</td>
</tr>
<tr>
<td>Swan (cockpit)</td>
<td>approximately 5 years</td>
<td>small</td>
<td>Forest Birds (Canada)</td>
<td>Mountain Birds (Romania)</td>
</tr>
<tr>
<td>Eagle (empennage)</td>
<td>approximately 1 year</td>
<td>small</td>
<td>Birds of Prey (UK)</td>
<td>Mountain Birds (Romania)</td>
</tr>
<tr>
<td>Albatross (skin section)</td>
<td>approximately 7 years</td>
<td>small</td>
<td>Sea Birds (Germany)</td>
<td>Elegant Birds (The Netherlands)</td>
</tr>
</tbody>
</table>

3Cases

The case studies were identified as Woodpecker, Swan, Eagle and Albatross. A short description of each case study follows.

3.1 The Woodpecker

The Woodpecker technology transfer was the transfer of an entire aircraft production line from the UK to Romania. The project started in 1978 and ended in 1990. For the SC it was attractive to transfer the Woodpecker production because it received payment for its (old) technology and it transferred responsibility for spare parts production. For the DC the project was appealing because it wanted to develop its own, independent aircraft industry. The choice for the Woodpecker technology was made jointly by the SC and the DC. The Woodpecker was chosen because for the SC it was an old technology (limited risk) and because for the DC it offered opportunities for improving its aircraft production capabilities. During the transfer the DC was struggling with gaining control of the technology. The DC was unaccustomed to UK work processes and it took a lot of effort to change accepted methods of working. In addition, it was difficult to apply UK methods in a Romanian environment. For example a problematic city heating system in Romania caused problems with applying sealant because this requires a specific temperature range. As a result, volume flexibility, modification flexibility, and delivery flexibility were all low [7].

3.2 The Swan

For the Swan technology transfer the Swan cockpit assembly was transferred from Canada to Romania. This project started in 1996 and is at present ongoing. The SC was attracted by the low wages in Romania and decided to transfer a small and stable technology. The SC, based on the technological capabilities of the DC, chose the Swan cockpit production technology. The Swan production technology was chosen because the DC was capable of producing the Swan cockpit without much training and technical assistance. Detail parts manufacturing activities and scheduling activities remained at the SC.
The SC gained volume flexibility and delivery flexibility to some extent. The Swan was a slow selling aircraft and the DC was able to handle the production times. It gave the SC the opportunity to use its existing capacity in better ways. Modification flexibility was low, the case study revealed many difficulties in the transfer of drawings and process information to another company (for example communication difficulties and technical mistakes). The DC did not receive the authority to modify the parts so modifications still had to be made by the SC [7].

3.3 The Eagle

For the Eagle technology transfer the Eagle empennage (the tail section of an aircraft) assembly was transferred from the UK to Romania. This project started in 1997 and is ongoing. SC’s primary motive for this technology transfer was the low wages in Romania. SC, based on the technological capabilities of the DC, made the choice of transferring empennage production technology. This technology was chosen because the DC was capable of producing the Eagle empennage without the need for much training and technical assistance. Detail parts manufacturing activities and scheduling activities remained at the SC.

The case study revealed that the SC did not gain volume, delivery and modification flexibility. The time schedule for the technology transfer was much delayed due to changes in the design and local production problems. Many of the production problems were related to problems with the exchange of production information leading to missing parts and technical questions. As a result the SC could not rely on the DC to deliver the right quality product at the right time. In addition, as mentioned in the Swan case, the DC did not have the authority to change the design [7].

3.4 The Albatross

For the Albatross technology transfer the production of an Albatross skin section was transferred from Germany to the Netherlands. This project started in 1998 and is ongoing. The SC’s motive for this technology transfer was its limited capacity. The production of the skin section implied inefficient use of existing capacity. The SC therefore chose to transfer the Albatross skin section production. After the choice of technology, the SC requested quotations for this work from several companies. Eventually a DC was chosen that could handle an entire package (detail parts production and assembly). This was determined by estimating the management capabilities (ability to plan and control), the technological capacity (ability to handle amount of work) and technological capabilities (ability to handle the required quality).

This technology transfer illustrated that the SC gained volume and delivery flexibility. The DC was capable of dealing with decelerating or accelerating delivery schedules. Modification flexibility was limited. The DC did not have the authority to change the design of the parts (although later in the project it was allowed to carry out minor changes) and SC-led design modifications required extra effort (due to a different production philosophy resulting in a more complex drawing structure) [7].
4 Result

The technology transfer processes that were analysed in the four case studies turned out to be essentially three different types of technology transfer, see Table 2 [7].

<table>
<thead>
<tr>
<th>Aspects</th>
<th>Sale of technology</th>
<th>Sharing of technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td>DC pays for a technology that increases its technological (and possibly managerial) capabilities.</td>
<td>The technology is more or less shared freely to benefit both parties.</td>
</tr>
<tr>
<td>Initiated</td>
<td>SC might have various motives (market: location, or technology: selling an unwanted technology) but these motives do not dictate the process.</td>
<td>A choice is first made by the SC about where production will take place (DC). After this, a technology is selected that fits with the capabilities and capacity of the DC.</td>
</tr>
<tr>
<td>Management calibre equality</td>
<td>The purchaser (DC) plans the use of the technology and is responsible. If necessary, and if it is affordable, it might get help from the SC.</td>
<td>Inequality will lead to some restrictions in the transfer, notably planning responsibility. Equality will lead to the transfer of a total package which includes planning responsibility.</td>
</tr>
</tbody>
</table>

Example case | Woodpecker | Swan and Eagle | Albatross |

Firstly, there is a difference between the ‘sale of a technology’ and the ‘sharing of a technology’. This was a contrast between the Woodpecker case study, where a technology was sold, and the others, where technology was shared. There were also differences between, on the one hand, the Swan and Eagle technology transfers and the Albatross technology transfer on the other hand. The first difference relates to the order of activities during the preparation, which was based on the motive for the transfer of technology. In the Swan and Eagle technology transfers, the sharing was initiated by selecting a location (and thus, in the aircraft industry, the DC) to benefit from lower costs. In the Albatross technology transfer, the sharing was initiated by selection of a technology because the existing capacity was inadequate. The second difference between
the Swan and Eagle technology transfer processes and the Albatross technology transfer was the management calibre. This affected the management tasks (responsibilities) that could be transferred. In the Swan and Eagle technology transfer processes, the calibre of management at the DC was not as good as at the SC, or at least it was perceived as such by the SC. In the Albatross technology transfer the parties were more equal. In the case of two equal parties an entire package is transferred, but if the parties are unequal then certain responsibilities (notably scheduling) are not transferred.

For both location initiated and technology initiated technology transfers the parties can theoretically be equal or unequal. The case studies covered only two of the possible combinations but this did not affect the knowledge gained of the technology transfer process because the characteristics of the other two combinations are logically linked.

With the sale of a technology, the reason for initiation is less relevant. With the sharing of a technology, it is more important because the first step (choice of location or technology) gives the boundary for the second step (the technology or the location). With the sale of a technology, this boundary is basically open and is part of the deal. If a complex technology is shared, then the DC needs to have high technological skills and this limits the possible DCs. But, if a complex technology is being sold, then the DC does not need to have high technological skills. Upgrading the skills of the DC should then be part of the deal.

The calibre of management at the DC compared to at the SC is also less relevant for the sale of a technology. Management calibre does affect the extent of technical assistance involved.

The flexibility gains in the four case studies were different. First of all, in none of the cases was modification flexibility achieved. This was due to the special circumstances of the aircraft industry (this is related to airworthiness regulations and liability issues). No volume and delivery flexibility gains were observed in the Woodpecker case. This was due to the type of technology transfer. In the three technology sharing cases some volume or delivery flexibility was achieved as a result of selecting an appropriate DC.

5 Discussion

Flexibility, as an issue of agile manufacturing, is related to the two types of technology transfer. This leads to insights for SCs and DCs.

5.1 Source companies and agile benefits

Companies striving for agile manufacturing are looking for flexibility [8]. Narasimhan and Das [2] state that “supply-base strategies would focus on the selection, development and certification of suppliers with the requisite responsiveness and technological competencies to fulfil operational agility goals”. This indicates that technology sharing is the appropriate type of technology transfer for agility. Within the technology sharing type of transfer there seems to be no reason to prefer a location initiated or a technology initiated transfer. However, the management calibre is an important variable. In the case of competent management at the DC an entire package could be transferred (including detail parts manufacture, assembly activities and the scheduling activities). In instances where the DC’s management was perceived as less competent, only a partial package...
(part of the production activities (assembly) was transferred while scheduling responsibility remained at the SC). To increase flexibility it would be preferable to transfer an entire package and thus competent management at the DC is sought. An effect of this is that the number of potential DCs in industrially developing countries is limited because many of these companies do not have the required management competencies as are available to companies in industrially developed countries.

5.2 Destination companies and technological development

It was shown in the Swan, Eagle and Albatross technology transfers that technology sharing does not significantly contribute to the technological capabilities of the DC because the DC is selected for its existing capabilities. These have to match the production requirements. For DCs in industrially developing countries to benefit from outsourcing of SCs in industrially developed countries for agility purposes, it is a requirement that these DCs possess the required skills (technical and managerial). Since in many instances the DCs’ capabilities are not sufficient, these have to be upgraded. It should be noted that upgrading will not result from technology sharing arrangements. In other words, the frequently used strategy of industrially developing countries to force aircraft manufacturing companies to use offset arrangements \[9\] does not by itself contribute to the technological development of these countries (or DCs), (see also \[10\] and \[11\]). Companies in industrially developing countries should therefore pursue alternative strategies to increase their skills so that they can benefit from outsourcing SCs.

6 Conclusions

Two distinctly different types of technology transfer can be distinguished: technology selling and technology sharing. Only technology sharing is an approach that can be combined with the agile manufacturing approach. Technology selling is less likely to be combined with the agile manufacturing approach because a requirement of agility is that the supplier has the required technological competencies which does not need to be the case in technology selling.

For an SC this means that technology transfer to companies in industrially developing countries is limited because of the limited technological capabilities of many companies in these countries. The management calibre at the DC is also important because competent DC management allows the transfer of complete work packages, thus increasing the flexibility for SC.

For a DC this means that when SCs increasingly aim at agile manufacturing approaches the DC will only benefit, by receiving work, if it already has a well established set of skills (both technical and managerial). If a DC does not have these skills, it should be aware that a forced technology transfer will lead to a technology sharing type of technology and thus no new skills will be learned (in this instance it will thus get simpler work).
References


