Judging The International Transfer Of Technology

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Abstract- International transfer of technology is a widely discussed area in the scientific literature. Although many different factors are discussed in the literature that affect the transfer of technology, it is not clear how to judge the performance of companies involved in international technology transfer. In this paper indications are given on how the performance of companies involved in the international transfer of technology can be judged. This is done by first explaining what is meant by international transfer of technology in the context of this paper. Based on this, a process model is developed for the transfer of technology. Several possible viewpoints of judging are given related to the efficiency and effectiveness of the technology transfer. However, judging the efficiency and effectiveness depends on the developed process model and is cumbersome and subjective. Therefore, the application of an alternative instrument, the learning curve is introduced. The learning curve offers great potential to judge the transfer of technology because it is an aggregate measurement of the production performance. Companies involved in a technology transfer have to be aware though that the learning rate can not simply be copied. The case studies lead to the conclusion that for the transfer process a constant curve is assumed but that in practice the learning rate at the Destination Company is lower than at the Source Company.

Keywords: international technology transfer, learning curve

I INTRODUCTION

The international transfer of technology is a widely discussed subject area. Publications from the 1970's and 1980's focused mainly on the selection of the technology and the channel of technology transfer for the multinational companies (see for example [Stobaugh and Wells, 1984]) and control for developing countries' governments (see for example [Bradbury, 1978; Sagafi-nejad et al., 1981; Technology Atlas Team, 1987]). In the 1990's, more issues have been included on the topic to increase the manageability of a technology transfer (see for example [Agmon and von Glinow, 1991; Chen, 1996; Ramanathan, 1999]). Many of the authors identified a range of factors that influence a technology transfer. Only recently, attempts have been made to develop a comprehensive theory on the international transfer of technology by looking at technology transfer as a process [Grant, 1997; Grant et al., 1997; Steenhuis, 1999b].
What is clear is that the international transfer of technology is a complicated activity for a company to perform. It faces many challenges and often the technology transfer leads to disappointments. What is not clear however is how to judge these disappointments. When performance is not in line with the original expectations, a number of possible explanations exist. First, the original plan (expectations) was correct but the actual performance was done poorly. Second, the performance was done good but the original plan was poor. Or third, a combination, both, the original planning as well as the actual performance were of poor quality.

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This paper contributes to the clarification of these issues. In section II, the international transfer of technology is clarified. In section III, criteria for judging the international transfer of technology are related to an on-going research project. In section IV, suggestions are provided for an alternative method; the learning curve. Finally, in section V, conclusions are given.

II TECHNOLOGY TRANSFER

It is necessary to determine what is actually meant with the international transfer of technology. There are many publications on the topic of technology transfer but not all these publications deal with the same technology transfer. Three mainstreams can be identified. First, there is literature on the transfer of technology from product idea (research) to the ultimate customer (distribution). This is known as innovation and it deals with three types of vertical, top-down, technology transfer: from research to development, from development to production and from production to distribution. Second, there is literature on the upgrading of technological capabilities in developing countries. This literature is termed exnovation by the authors to indicate technological development directed mostly from outside the company in contrast with innovation where technological development is directed mostly from inside the company. Exnovation deals with three types of vertical, bottom-up, technology transfer: from distribution to production, from production to development and from development to research. Third, there is literature that links these two concepts. This covers ten types of technology transfer. Four types of horizontal technology transfer and six types of diagonal technology transfer. This is schematically represented in the Technology Building [Steenhuis and de Boer, 1997].

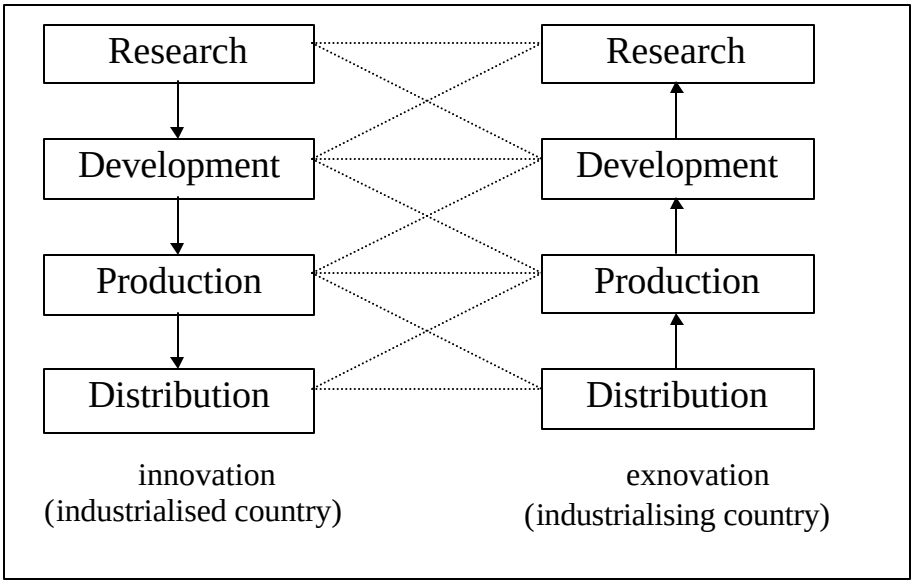

Figure 1: The Technology Building

This paper focuses on the horizontal transfer of production technology.
Viewing the transfer of technology as a process can lead to important insights on how to improve management. There are several types of processes [van de Ven, 1992]. The viewpoint taken here

is that technology transfer[2] can be seen as a teleological process, there is a movement towards a final goal or state. The final goal or state for technology transfer is the production at the Destination Company with a comparable productivity as the Source Company[3]. Research on this process of technology transfer led to the Technology Transfer Balance [Steenhuis, 1999b]. The model is called the Technology Transfer Balance for several reasons. First, to indicate that the sides of the Source Company and the Destination company need to be balanced. Second, to ease the transfer of technology, it is necessary that the Source Company and the Destination Company are balanced with each other. Third, the transfer of technology might lead to an unbalanced Destination Company side. It is important to be aware of these balances.
The Technology Transfer Balance contains three main parts (for elaboration see [Steenhuis, 1999b]). First, the technology that is transferred has certain characteristics as depicted by the P in the technology circle. Second, there are three phases for technology transfer: prepare, install and utilise. Third, there are three sets of factors: technological factors, organisational factors and environment factors. This is represented in figure 2.

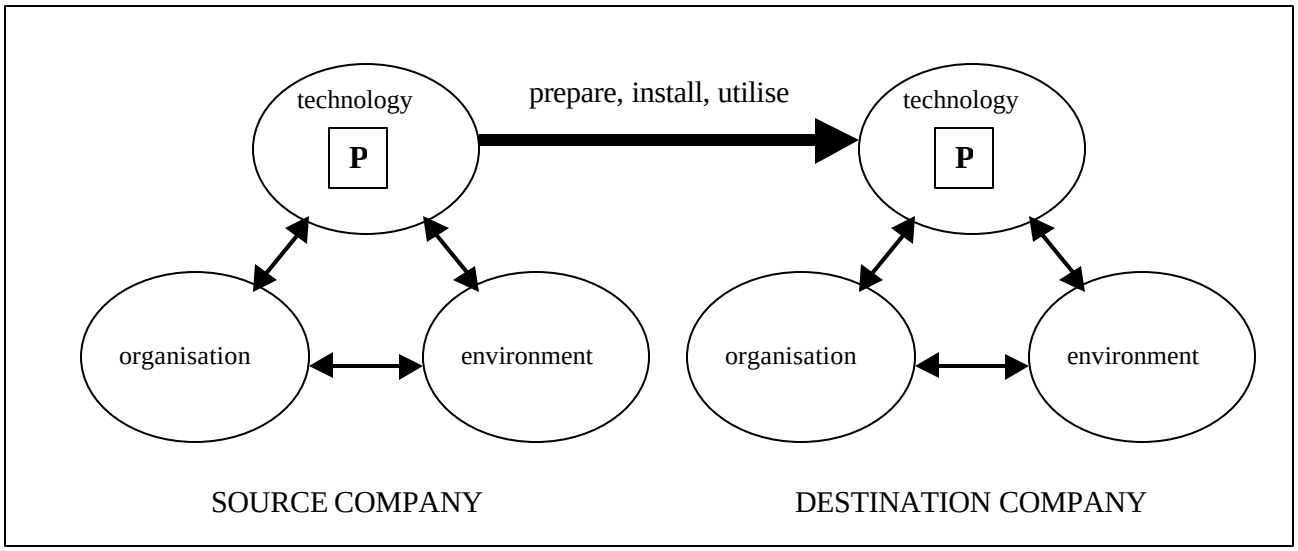

Figure 2: The Technology Transfer Balance

III CRITERIA BASED ON THE PROCESS MODEL

To determine the success of a technology transfer criteria need to be developed. These criteria are basically indicated by the different parts of the Technology Transfer Balance. If factors and their influences are known, the actual performance of a technology transfer can be judged.

[2] From this point forward, the terminology 'technology transfer' relates to the 'international transfer of production technology'.

[3] The terms Source Company and Destination Company are used rather than frequently used alternatives in the literature. Most frequently terms such as 'home and host' or 'sender and recipient' are used. The term host was considered inappropriate because this indicates a feeling as if the technology is a guest. This may sometimes be the case, as in a subcontract, when the home may decide to put the technology also elsewhere, but this is certainly not always the case. On the other hand, sender and recipient were also regarded as not feasible. The reason is that this gives the impression as if the sender can just easily send 'something' (freely) and the recipient just needs to receive it. The terms Source Company and Destination Company indicate that a technology originated in a particular situation (the Source Company) and is transferred to a certain destination, having different characteristics (the Destination Company).

However, there are still multiple possible criteria depending on different viewpoints. For example, it is possible to look at economic benefit, technological benefit, social impact etc. Here, the viewpoint is taken that to judge the process, there are in essence two criteria namely the efficiency of the transfer and the effectiveness of the transfer. Effectiveness stands for real results compared to norm results. Efficiency stands for norm sacrifice compared to real sacrifice [In't Veld, 1992]. These criteria can be split for the company level and the country level. At the same time, success of a technology transfer is related to expertise, namely the build up (transfer) and use (after the transfer) of technological expertise. This leads to several criteria as indicated in figure 3.

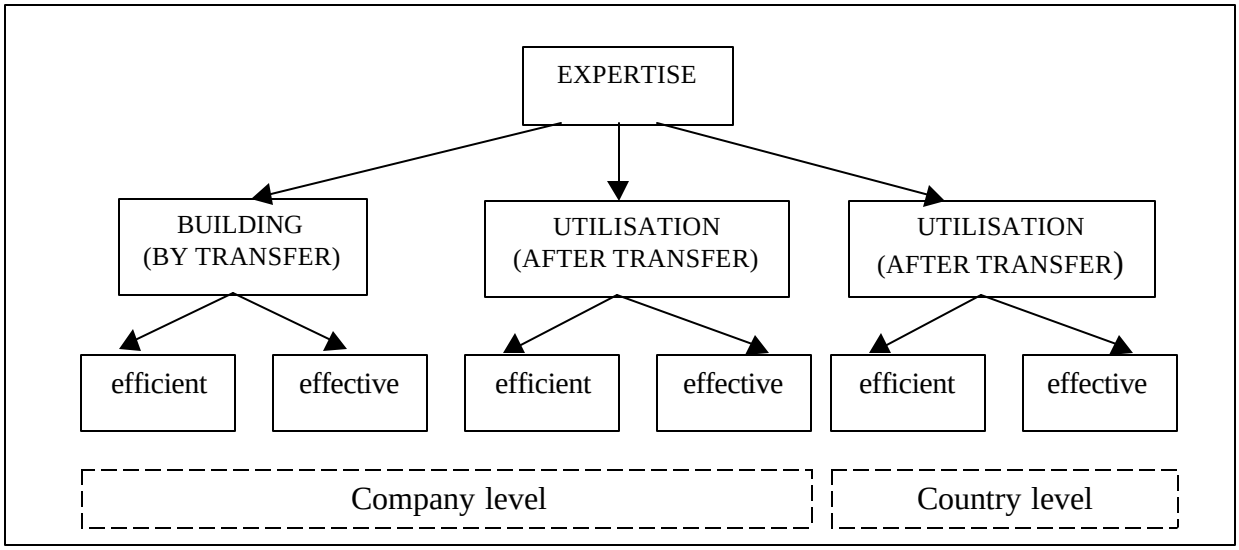

Figure 3: Criteria for technology transfer

A research study was started at the Technology and Development Group to describe the international transfer of technology [Steenhuis and de Boer, 1998]. One of the research projects was executed in the aerospace sector, in which four case studies were carried out. The first case study involved the transfer of the entire production of an aircraft structure [Steenhuis, 1998a], the second case study involved the transfer of aircraft cockpit production [Steenhuis, 1998b], the third case study involved the transfer of production of aircraft tails [Steenhuis, 1999a], and the fourth case study involved the transfer of aircraft skin panel production [Steenhuis, 1999b].
The case studies were designed to identify the range of factors that influenced a technology transfer and to determine whether or not the technology transfer could be judged successful. In the case studies judgements were made on the efficiency of the expertise building and the efficiency of the expertise utilisation at the company level. With the increasing knowledge of the technology transfer process (Technology Transfer Balance), the judgements can be better made. Because the better the process model, the better one is able to judge the circumstances and the performance of the companies because it is known what to look at. However, since each case study involved a multitude of factors and since the judgement was subjective in nature, the need was identified to look for alternative and more objective ways to judge technology transfers.

IV THE LEARNING CURVE

Although better criteria were not found in the technology transfer literature, a potentially helpful alternative instrument was found in the industrial engineering literature. The instrument is known as the learning curve. In all of the four case studies, the learning curve was applied to determine the production man-hours at the Destination Company. In three of the four cases, related to an industrially developing country, the learning curve was mainly determined by the Source Company. The use of the learning curve makes it possible to pre-determine the length of the install phase and the production during the utilise phase. Although the actual man-hours were difficult to measure in each case study, the data showed that the actual learning curves were different than the pre-determined learning curves [Steenhuis, 1998a; Steenhuis, 1998b; Steenhuis, 1999a; Steenhuis, 1999b]. Figure 4 illustrates from empirical data the difference between planned delivery dates with the use of the Source Company learning curves and the actual delivery dates at a Destination Company. It shows clearly how much the actual results deviated from the planned results (although more than eighty aircraft were supposed to be produced, less then ten were produced).

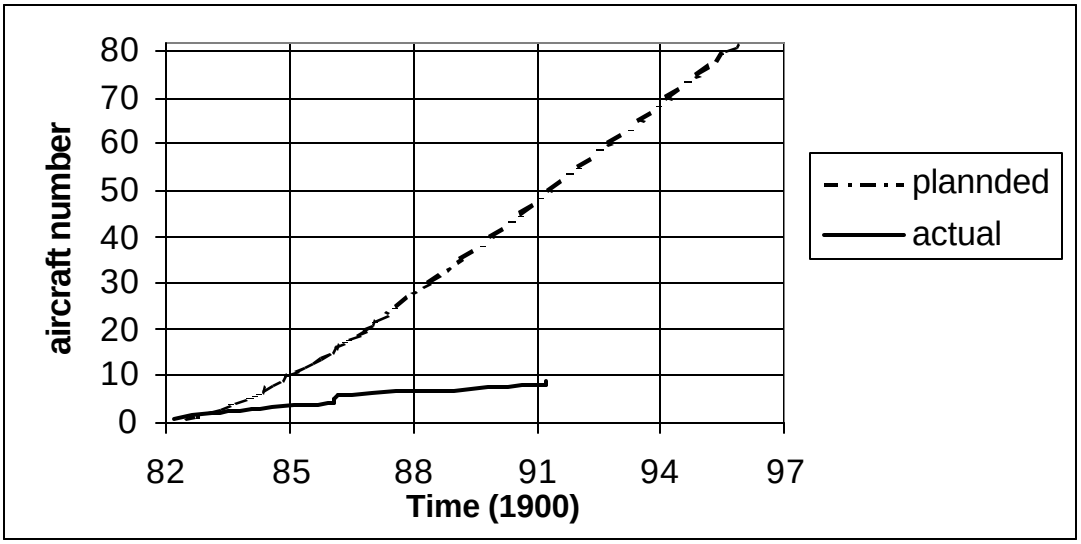

Figure 4: empirical data on a technology transfer project

In effect, the Destination Companies used the pre-determined learning curves and thus deviations were treated as undesired and consequently not successful. However, based on the observations in all the case studies, it is proposed that instead, the learning curves themselves might have been based on the wrong assumptions.

The learning curve dates back to Wright who identified that the number of man-hours needed to produce a certain aircraft declined the more aircraft were produced [Wright, 1936]. It has been empirically observed that resource input necessary to complete a unit of production will decrease by a constant percentage each time the production quantity is doubled [Nanda, 1982]. But there are significant differences in learning rates for different industries, different firms, different products, and different types of work [Conway and Schultz, 1982]. Some important adaptations have also been made to the original model, for example by DeJong and the Stanford Research Institute [Smith, 1989]. DeJong showed that not all types of production activities are improved

with increasing production. The Stanford Research Institute included a learning benefit carried over from the production of prior products. Although a range of factors have been identified that influence the actual shape of the learning curve [Smith, 1989], the actual learning itself is not yet clearly understood.

The concept of the learning curve offers great potential to judge the success of technology transfer. The learning curve relates to an observable, aggregate measurement of productivity improvement. So whereas using the criteria based on a process model results in checking all the relevant factors and activities and then judging (subjective) the performance of the companies, the learning curve circumvents all the factors but gives an aggregate measure of the performance. Especially when a technology is transferred that has already been used by the Source Company, certain information is already known about the technology such as for example the number of hours necessary to produce a product when the production line is stabilised which increases insight into the learning curve at the Destination Company. However, the companies involved in a technology transfer need to realise that the learning curve can not simply be copied from the Source Company.

Levi [1982] distinguishes three types of learning: planned or induced learning, random or exogenous learning, and autonomous learning. Planned or induced learning is learning that results from the firm's applying techniques that are designed to increase the rate of output or equivalently to reduce the costs. At the Destination Company this is likely to be less than at the Source Company. This is because changes in the design have already been made by the Source Company. Thus, an important aspect namely pre-production planning is well developed, this reduces the learning rate. Second, random or exogenous learning may also be less at the Destination Company. Random or exogenous learning consists of improvements in production processes that can result when a firm acquires information unexpectedly from its environment. The learning curves that are established in the literature are mainly derived from a specific type of environment, the United States and Western Europe. When a technology is being transferred to an industrially developing country, it is questionable whether the same rate of learning can be achieved. Especially poorly developed local industries (notably suppliers) might not lead to the same rate of random or exogenous learning in developing countries. Third, autonomous learning, improvement due to on-the-job learning or training of employees, might also be less in developing countries due to differences in education, experience or motivation (incentives) of the workforce. Based on these insights, it is proposed that the learning rate at the Destination Company is lower than the learning rate at the Source Company. However, how much lower the learning rate should be is not clear because the influences of different circumstances on the learning curve are not yet understood.

V CONCLUSION

The concept of the learning curve is a potentially powerful tool to determine the efficiency of especially the install phase and the utilise phase. Because conditions are known (or can be known) for a more or less stabilised production at the Source Company, the end result of the technology transfer is to a large degree pre-determined. With the application of the learning curve this means that estimates can easily be made for the duration of the install phase and to a lesser extent for the utilise phase. Based on the experiences in a range of industries and for a range of products and processes, it can be expected that the learning curve can also be applied in different environments. The big disadvantage of the concept so far is that the exact consequences of different environments are not clear. However, as was indicated in section four, it is likely that

the learning curve rates differ. Based on this, it is proposed that the Destination Company uses learning rates lower than the learning rate of the Source Company.
Further research needs to be done on learning curves in different (national) environments to identify the influence on learning rates of different environments. The learning curve concept needs to be developed further to determine why the learning curves exist and what influences the learning curve. The environment is likely to be one of the influencing factors. Besides that, the industry, organisation, production processes and the product itself all are influences on the learning rate. Once it is determined how each of these factors influences the learning rate in a specific situation, a more objective judgement on the international transfer of technology can be realised.

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