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ABSTRACT

This paper considers the need, conditions and mechanisms for succesful technology transfer towards the European Assistive Technology industry. The discussion reveals the role of non-profit institutions in initiating and sustaining a reasonable level of technology transfer, since the industry is not likely to achieve this by itself. In particular, it is argued that, given the impediments to successful technology transfer discussed in the paper, there is a need for an organisational body to access the needs of the industry, evaluate alternative potential sources of technology based on their relative merits and synergies, coordinate sources and recipients and provide a minimum infrastucture for such transfers to materlise. To this effect, a cluster of general mechanisms for transferring technology from one place to another is reviewed, and a set of criteria are introduced depicting a tentative evaluation of each of the mechanisms being considered with regards to its contributions towards design for all.

KEYWORDS
Mechanisms for Technology Transfer, Innovation adoptiveness

Introduction

The transfer of technology from one area to another is not just a recent phenomenon. It has been going on for a long time, although its scale and impact have vastly accelerated in the past 150 years (Rosenberg, 1982). Technology transfer is a complex affair, which has been extensively studied in a variety of contexts and for a multitude of purposes. Its aim is to transform the results of research into working prototypes or designs, and then into innovative assistive technology products. The existing literature on technology transfer may be divided into:

- Studies which emphasise the *economic* factors underpinning the process of technology transfer. These studies view technology transfer merelky as an *economic rent*.
- Studies which impose a *policy-oriented* view of the process. These address technology transfer at different scales and levels (i.e. international, industry and company levels) as well as the critical issues underpinning this process.

Early studies on technology transfer focused on the *economic factors* underpinning the process. The emphasis on purely economic factors implied a definition of technology transfer which was mainly driven from the traditional economic theory and looked upon the process of technology transfer as an *economic phenomenon*. According to this view, technology is seen as largely an exogenous element which develops and matures in some

way, and which, ultimately, becomes available in the market to be sold and purchased as any other commercial product.

More recently, researchers have proposed alternative definitions for technology transfer which cover additional aspects. These look at such transfers from institutional, organisational, human and technological points of view, and also consider issues such as technology transfer between organisations, industries and economies. This latter perspective suggests a *policy-oriented* view upon transfers of technology which focuses on a broader spectrum of issues, of which technology is only a part.

The motivation and rationale for such studies, however, have been different (Resenberg, 1982). For example, studies focusing on international technology transfer may concentrate on the impact of this transfer upon the country of origin. Others explore the impact of transfers of technology upon the recipient country. Yet another group of studies considers the conditions for successful technology transfer, and so forth. In all cases, the authors converge to conclude that the successful transfer of technology is not simply a matter of transferring a piece of hardware from one geographic location to another. It often involves much more subtle issues of selection and discrimination, and a capacity to adapt and modify before the technology can function effectively in a new socio-economic environment. These conclusions, based upon widespread nineteenth-century experiences, are intended to suggest that the successful transfer of technology depends greatly upon the specific circumstances in the recipient country, industry or company.

In the context of the poresent work, technology transfer is the process whereby a particular technology, either in embodied (e.g. products, machinery and equipment), or disembodied (e.g. knowledge, information, awareness, etc) form is transferred from one area to another via appropriate mechanisms and links. Our motivation for studying the transfer of technology towards the European assistive technology sector rises from the observation that the level of innovative activity within this sector is very low compared to other industrial sectors. Moreover, this sector of the industry is certainly not a natural generator of innovation, and neither is it a good recipient of new technology. The position of this study is that given the present structure and operation of the assistive technology field, there is a compelling need for the identification, analysis and transfer of new technologies towards this industry, in order for industrial innovation to be induced, encouraged and supported, if this sector is to perform any differently than in the past. This implies that the sector must become aware of new technologies and also that appropriate mechanisms will be needed to sustain the transfer of new technologies and to induce and generate innovative activity.

The Need for a Technology Transfer

It has already been argued elsewhere (Vernardakis et. al., 1995) that the structure, composition, level and type of competition, size of firms, direction of production and the limited and inefficient interaction among the market elements lead to a low uptake of innovation in the Assistive Technology market in Europe. According to a recent survey (TIDE-CORE, 1993) covering several of the EU and EFTA countries, producer firms in the Assistive Technology industry were found to be small and very small, operating as oligopolists in a market characterised by adaptation-oriented product rather than price differentiation. In the majority of cases production of Assistive Technology products appears as complementary to the producers' other lines of production, while in a number of cases producers of goods other than Assistive Technology products appear as producers while in effect they are simply traders in such products. Innovation is badly served as very few producers perform any research (12.5%) and development (30%) and while not directly derivable from the survey, accompanying circumstances seem to indicate that even that

research is of an occasional rather than a permanent character. In essence therefore, the little amount of innovation that seems to take place does so mainly in organisations, institutions for instance, where the overall small amount of research seems concentrated.

If the objective is to have a European Assistive Technology industry that is responsive to users needs and able to hold its own on the international market, then it is clear that the present industry should become significantly more innovative or receptive to change. Given the cumulative and firm specific nature of innovative capability (Teece, 1988) and the present state of innovative effort and capability in the Assistive Technology industry, it is clear that left on its own there is no particular reason for the sector in question to perform any differently than in the past. On the other hand, if a successful transfer of technology can be achieved, then there are reasons to believe that the objective set previously has some chances of success.

This paper investigates the conditions for succesful technology transfer and reviews and compares the relative merits and potential of a cluster of mechanisms for transfering technology from one place to another, in the context of the European Assistive Technology industry.

Type, Sources and Recipients of Technology Transfer

Until recently, technology transfer used to be investigated as an economic rent. In this article, transfer of technology will be considered from a totally different point of view, namely, it will be considered as a real transfer of knowledge. In this sense, while embodied technical change is allowed, it is most likely to appear only in research equipment and machinery, while in most cases, technology transfer will be represented by its disembodied manifestation. Our main interest therefore concerns transfer of knowledge, information patents and learning, either clearly articulated as written documentation or oral teaching, or it may be tacit and capable of being learnt only through "learning by doing". With respect to innovation, technology transfer here is meant to cover all stages, that is, both pre-innovation as well as post-innovation, and thus cover from basic research to full scale manufacture, the marketing of innovations and their diffusion.

Given the considerable variations in the way firms view and operate within the Assistive Technology market we can distinguish four types of firms (Stephanidis et. al., 1994a). The first group consists of high technology SMEs who consider their underlying technology as their competitive advantage and which may or may not understand user needs. The second group consists of larger firms who are basically outside the field but are linked to it through co-operation or acquisition of firms within the Assistive Technology industry, and through production of some products akin to the Assistive Technology market while complementary to the rest of their activities. In contrast with the above two types of firms there are two more types: one consisting mainly of small to medium sized firms entering the market strategically with objectives of long term survival in the field, while the other one consists of firms who have long been in the field and which lend to it most of its characteristics.

Thus, out of the four types of actors two are fully committed to the Assistive Technology market, namely the two belonging to the latter group. It is precisely these two types which stand as pure potential recipients of a technology transfer while the first type of firms could be either a potential recipient or a potential source. As for the second type of firms there is no obvious reason for it to appear either as a source or as a recipient.

Unlike industries which depend basically on a single technology, such as biotechnology, the Assistive Technology industry, by the nature and the versatility of its

present and potential products, is a potential recipient of technology transfers from a multitude of other sectors and may depend on a multitude of technologies.

From the above, it follows that most of the potential technology transfer will be of the inter-sectoral type rather than the intra-sectoral one. If any intra-sectoral transfer develops it is most likely to involve the type of firm we have identified above as either potential source or recipient. If such a situation develops the transfer will very likely be part of a stronger collaboration among the two firms.

While the potential recipients are clearly the firms of the European Assistive Technology industry there are no distinctions as to the institutional nature of the sources, which organisationally could be firms, higher education institutes and public research establishments.

Conditions for the Successful Transfer of Technology to the European Assistive Technology Industry

For the successful transfer of technology to take place towards the European Assistive Technology industry a number of conditions will have to be met. Some of these conditions are very general and therefore their applicability is irrelevant as to sectors while others are sector specific and therefore will relate to the Assistive Technology industry specifically. We propose to start from the most general then proceed to the more specific (Figure 1).

The Basic Condition of Success vs. Failure

Whether a transfer of technology takes place or not the final outcome we are interested in is whether firms are in a position to become innovative. Taking into account the large number of studies performed in attempting to identify the most important variables behind successful innovation (Mowery et. al., 1979; Rothwell, 1977; Rothwell et. al., 1979), a few very basic conditions, commonly accepted ones emerge: "understanding of user needs" and "good communication and effective collaboration" stand out not as mere conditions to be met, but as sine qua non: their presence is associated with success and their absence is associated with failure.

Strictly speaking, "understanding end user needs" is not part of the technology transfer process proper but by its nature it effects a number of decisions that relate directly to that transfer, starting from the scope of the research for sources down to the evaluation, assessment and choice of the technology or technologies to be transferred.

This means that we are already facing a problem and a serious one at that since we have identified in the past (Stephanidis et al., 1994b) that an important part of demand is "filtered" demand where end user preferences pass through experts before being expressed. While this situation is widely acknowledged, the severity of this condition is validated in the case of the Assistive Technology market to a degree that could hardly be emphasised more emphatically. Indeed, in the survey we have already mentioned, covering a number of EU member states as well as some EFTA countries (Teece, 1988), the overwhelming majority of the totality of actors involved in the Assistive Technology market, identified "understanding of end user needs" as by far the first and most important influencing the demand for Assistive Technology products and services. More analytically, the percentages of the participants in each group within the Assistive Technology industry which considered "understanding of end user needs" as important was the following: actors in research 91%, development 74%, production 88%, trade 82%, procurement 44%, delivery 59%, usage 72%. It looks therefore as if we are running against a condition that is very difficult to satisfy.

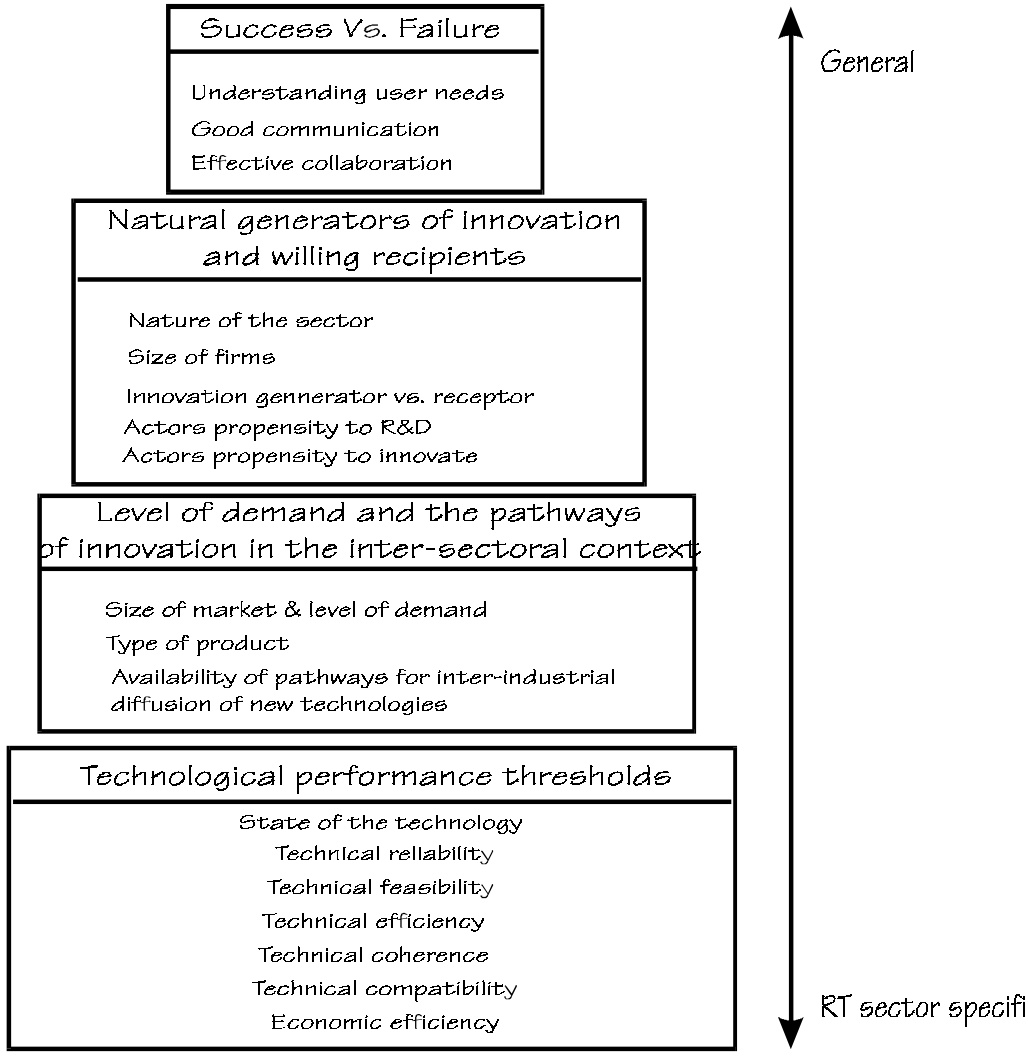

Figure 1 : Overview of conditions for succesful Technology Transfer towards the RT industry

Natural Generators of Innovation and Willing Recipients

Several Studies (DeBresson et. al., 1993) have proved that innovation is not equally distributed among activities. Innovations tend to cluster in a number of activities - generators of innovation - while other activities are not characterised by their innovativeness. As for the recipients, there are activities which are receptive to innovations taking place in other sectors and activities which are not so receptive.

Studies performed for Italy (DeBresson et. al., 1993), the U.K. (Geroski, 1991), and Greece (Vernardakis, 1993; Vernardakis 1994), show that two conditions come into play in determining the degree of innovativeness of a sector in a particular country : the nature of the sector and the size of the firms involved. Some sectors are "natural" generators of innovation, such as "engineering" and "software and information technology" sector irrespectively of the level of economic development of the country in question - probably beyond a certain threshold economic development level achieved.

Size of firms involved appears as an additional limiting condition. "Chemicals" for instance, is a "natural" generator of innovation and performs admirably in the U.K. and Italy

and thus seems to thrive in a large firm environment where substantial R&D is performed, but performs poorly in the case of Greece where large firms are missing from that sector.

For our purposes, what matters with respect to the above is first, that the AT industry is definitely not a "natural" generator of innovation and it is less than a willing recipient. If a transfer of technology is to take place, then the AT industry will have to become more receptive to change. Additionally, since as we have already mentioned, it constitutes an activity which could potentially receive technology from a number of other sectors, choices will have to be made as to which transfers should be considered, and of course these choices will have to be limited to sources which are both "natural" generators of innovation as well as willing sources, since technology is not necessarily accessible. This last item is of importance since our definition of a technology transfer does not limit itself to information. While a mature technology could be considered as accessible the same cannot necessarily be said of a new or emerging one.

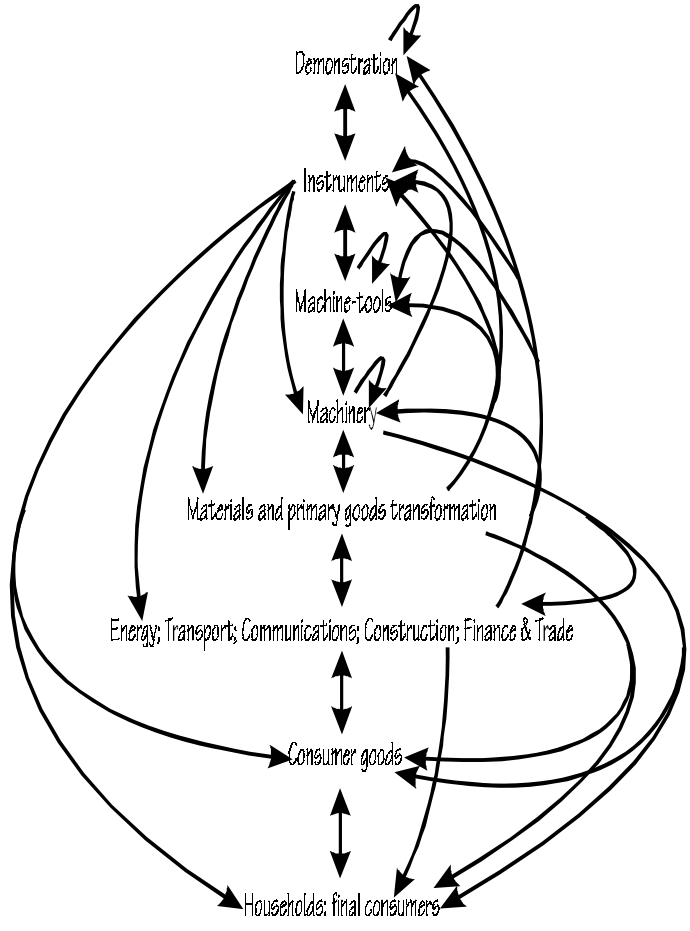

Figure 2 : Pathways of innovation

It should also be remembered that in any contemplated transfer of technology the condition on the size of firms will have to be met as most of the firms in AT industry in its present composition and structure tend to be rather small - unless it is envisaged to lure larger ones. The question of size is of special relevance to the two types of firms that seem committed to the AT market.

The Small Level of Demand for AT Products and the Pathways of Innovation in an International Context

In a path-breaking article DeBresson (DeBresson, 1991) has shown that innovation at the international level, that is, the least well studied variety, is not a random process but follows rather predictable pathways. While we shall not reproduce DeBresson's complete argument here we shall make use of his diagram (see Figure 2).

He demonstrates that asymmetries in circulation considerably reduce the number of pathways for inter-industrial diffusion of a new technology. An example of such asymmetries can be found in the case of households, which provide their services (manpower) to all sectors, but they don't purchase machine tools or machinery while instead they are the only purchases of subsistence goods and consumer durables.

In the same line of argument, the nature of AT products is such as to place then close to but not within either the subsistence goods group nor the consumer durables category, while end users of AT products do not fit themselves in the plain category of households. If we additionally take note of the fact that the AT market is small relative to the rest of the market, then we realise that a transfer of technology towards the AT sector is a difficult undertaking since the pathways for inter-industrial diffusion of new technologies are limited, considerably more limited than in the case of subsistence or consumer durables.

Technological Performance Thresholds

In any technology transfer, the minimum requirements for acceptability are a question of primary importance. In our case, where the AT industry is anticipated to be the recipient, the expectations, given the very limited propensities in R&D in that sector, should be for the transfer to take place once the technology involved has reached its most advanced level. In the Technology Life Cycle (TLC) model (see Figure 3), a technology reaches its most

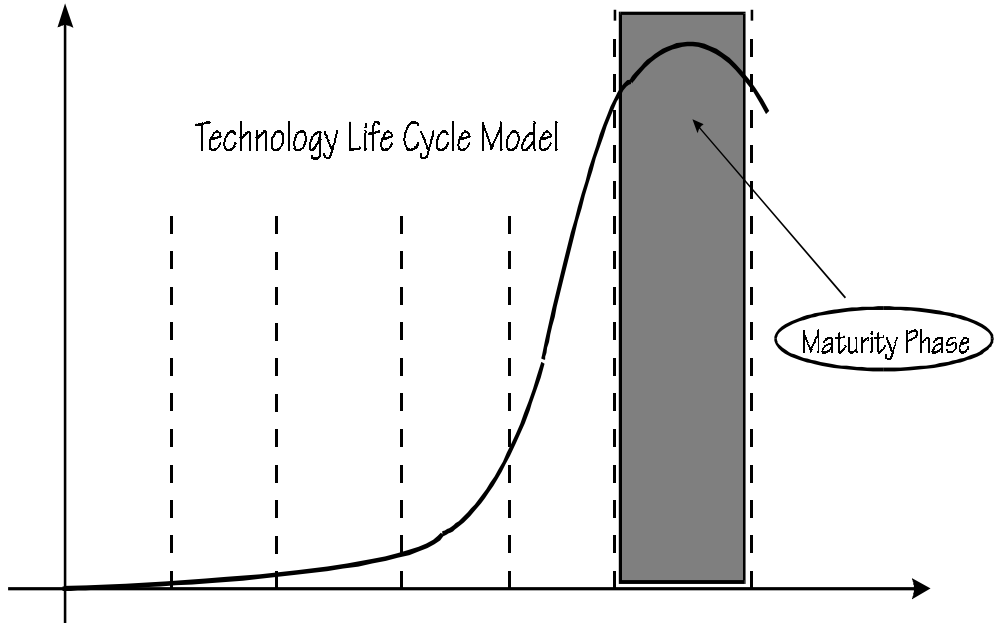

Figure 3 : The Technology Life Cycle model

advanced level once it enters the maturity stage[1].

[1]Prior to the technology maturity stage, explorative and preparatory studies (i.e. awareness regarding the new requirements of disabled and elderly people) could be emphasised to influence the technology's life cycle and demployment so that potential discriminating effects are reduced or eliminated. This signals the requirement

Nevertheless, independently of the state of the technology at which the technology transfer takes place, the requirements put upon the state of the technology in use are rather high. In other words, while technical feasibility may be an attribute sufficient to satisfy the needs of what DeBresson calls the "demonstration" sector, -meaning state research laboratories, military research of the medical sector- it is far from being sufficient to satisfy the needs of the AT sector. Technical reliability is an attribute of higher order than technical feasibility for it presupposes the latter and adds to it. Nevertheless, although it may be a sufficient attribute for a sector such as "instruments", it falls short of the expectations for the AT industry.

Strictly speaking, even technical efficiency, which presupposes both technical feasibility and technical reliability and would be appropriate for a sector such as "machine tools", would still be an insufficient attribute. What is really needed is economic feasibility in the long run, leading to versatility and economic efficiency. Coherence and compatibility may be desirable but they are not necessary in the sense that they are hardly to be met in a situation of potential transfers from a diversity of sources as in the case of the AT industry.

Besides the technologies involved, the nature of the products and services of the AT market is such as to make them unique among product and services groups. For instance, within consumer goods, it is expected that in luxury goods new utility is addressed, in mass luxury goods user friendliness is expected, in durables standardisation is offered, while in subsistence goods cost advantage is a feature. Econometric studies on the determination of demand behaviour within the AT market are still to be performed, but one would hardly err in the wrong direction by saying that the transfer(s) of technology should be such as to address the issues of new or enhanced utility, of conviviality (user friendliness) and of standardisation. Cost advantage is a desirable property which in some cases may not show its full weight as part of demand in the AT market is expected not to be as price elastic as it could due to the fact that part of demand is covered by national security schemes or similar arrangements. Price elasticity is expected to play its full role in the part of demand that is "private".

Technology Transfers and Information Flows

Information flows are vital to technology transfers. They are essential to collaboration among entities and thus essential to technology transfer which is a process involving at least two entities and information flows linking them.

Distance, accessibility and cost seem to be the factors affecting most significantly the important sequences in inter-entity technical collaboration. A number of studies indicate a typical distance decay function in communication (Allen, 1977), that accessibility to communication channels and their ease of use affect information flows (Chakirabarti et. al., 1983), and that size and information linkages are affected by cost.

The sequence in inter-entity technical collaboration which have been subdivided into five (Rogers 1982), even eight (Johnston et. al., 1975) activity phases, essentially refer to four basic activities (Charles et. al., 1992): scanning with the object of locating a suitable entity for a collaborative partner; decision-making as to the choice of the partner; day to day management of the technical collaboration; and the use of effective information flows for the successful completion of the project thus leading to the implementation of the launch or adoption of a new product or process of an innovation.

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for an early technology transfer in the form of information flow from the RT sector towards the developers of a new technology.

Additionally, we may distinguish some other factors affecting the flow of information between the two entities such as the nature of the technical collaboration, which may range from basic research to the licensing of an existing technology, differences associated with the type of the entities involved, the type and spatial environment related to the entities involved. To put it simply, it makes a difference whether we are considering a situation where the collaboration characterising the transfer has to do with a project in basic research involving a global multinational corporation, in contrast with dealing with a simple license involving a small single-site domestically oriented firm operating in the periphery.

From the issues raised above, a number of implications follow and among them the ones most salient are those hinging on size of firms. This is especially true with respect to two of the stages described previously, namely, scanning and decision making. It is a well established fact that smaller firms have much smaller scanning fields than larger, multi-site companies, especially multinationals. This means that the ability of smaller firms to be aware and to identify collaborative partners is much smaller than in the case of larger firms to identify potential collaborative partners among smaller firms. Additionally, in the screening and decision-making phases, the role of the technical "gatekeeper" becomes absolutely essential.

Some mechanisms for transferring technology

Having reviewed, the conditions for successful technology transfer towards the European Assistive Technology industry, let us know shift out attention to the issue of mechanisms for transferring technology from one place to another. Our aim is to investigate the feasibility of these mechanisms in the context of the AT industry and to arrive at a tentative assessment of their implications and potential value in this industry.

1. Licensing

This form of technology transfer involves a company buying a licence from another company, which permits it to use the latter's patent on a certain product or process, for an agreed period of time. This licence may give the buyer exclusive rights, that is, allow it to be the sole producer in a country or in a predefined region. If a company wishes to produce compact discs, for example, it will have to purchase a licence from Philips or Sony, who are the inventors and hold international patent rights. The purchaser will, of course, have to pay the holder of the patent for the right to produce compact discs. Such payments usually last for the duration of the agreement and usually represent a percentage of total profits from the sale of the CDs by the purchaser.

In addition to these payments, the patent holder will often impose some restrictive clauses on the buyer, such as forbidding the export of the products, and obliging him to buy inputs, machinery and spare parts from the supplier of the technology. Sometimes there is even an obligation not to conduct further research and development on the product that is licensed.

2. Purchase of patent rights

When using this type of technology transfer, a firm purchases all the patent rights from the company which owns the technology, as well as the technical drawings and manufacturing information. The difference between this type of technology transfer and

licensing is that with the latter the agreement between supplier and purchaser lasts for an agreed period of time, after which all the rights on the technology continue to belong exclusively to the supplier. In the case of the purchase of the patent rights, the purchase holds for the legal duration of the patent, and until it expires.

For instance, in using the previous example with the CDs, the company might wish to purchase the patent rights from Philips, rather than buying a licence. Of course, under normal circumstances, Philips would never sell its CD patents, but this is only intended to be a hypothetical example.

3. Purchase of technical advice

Under this situation, a company sells its technical advice and help to another company interested in the particular technology. Many agreements include a clause to the effect that the technology supplier has to keep the purchaser continuously informed of any modifications, improvements or developments brought about by the former. In a few cases, a firm may ask for technical help on R&D issues, but this situation is rarely encountered and depends on the capabilities involved.

Some technical advice and knowledge may be available in the form of documents, drawings, or computer files that are easily transferable between the parties. It is, however, far more difficult to transfer the equally important but intangible knowledge that the original company has acquired as a result of its experience in a particular field of technology. In many cases this type of knowledge can only be transferred by direct contacts with the key personnel of the firms in question, and it can often be beneficial if arrangements are made for an appropriate staff member from the company which is selling the advice to spend a period of time working with the purchasing company.

The success of such technical advice purchase schemes depends very much upon the existing state of knowledge of the purchasing company, and on its willingness to receive new knowledge and to innovate. It is much easier for a dynamic firm that is up to date in its general understanding of new technologies to successfully purchase the information it needs than it is for a company which has failed to keep pace with modern technological developments. Such "backward" companies would need to try much harder in order to understand and internalise the advice of the technology supplier, and this type of arrangement may not therefore be appropriate for them.

4. Technical support

It is sometimes difficult to distinguish technical support agreements from the technical advice agreements discussed in the previous section. Technical support usually deals with the recipient's practical needs in terms of product design and production, material inputs and the supply of intermediate products, machinery, spare parts and maintenance, quality control, etc. Technical support agreements can usually be thought of as providing solutions to day-to-day, routine problems. In contrast, technical advice agreements are usually long term ones and broader in scope, in the sense that the supplier not only sells the technology and its related know-how, but also informs the buyer of any possible improvements, and maintains the machinery of the latter for the duration of the agreement. In many instances the technology supplier will be expected to provide both technical advice and technical support, and it will therefore be important for the partners to ensure that their agreements reflect their common understanding of what is required.

5. Contract research and development

Under contract research and development agreements, the technology supplier conducts a research and development programme on behalf of the purchaser and to the latter's specifications. Such agreements are usually made when the purchasing firm needs to solve a specific problem which is either technically or financially beyond its present capabilities. These agreements are often made in order to sort out problems relating to production, industrial design, or quality control.

6. Co-operative R&D

When a technology is new and showing great potential, but will involve considerable financial risk, its development costs may be too high for one firm to carry alone. In such cases, co-operative R&D agreements can prove very useful in sharing risks and costs. They also provide an effective way of avoiding duplication of effort and overlapping research projects. Non-market institutions, including national governments and the TIDE office, play an important role in promoting co-operative R&D efforts. Some act as co-ordinators, some as capital suppliers and some as clients for those wishing to carry out such R&D; other institutions take on all of these roles. Co-operative R&D can lead to very high quality technological research which can affect the whole work of the companies involved, sometimes leading to the reorganisation of the companies and changes in the production systems that are used. Experience suggests that firms involved in co-operative R&D should, above all other considerations, be complementary to each other. The end result of such co-operative R&D may then be a product of the technological synergies that have arisen between the companies. It can be argued that co-operative R&D projects may be the most common source of technological synergies, and vice versa.

Additional characteristics of technology transfers via co-operative R&D are:

- Highly capable and innovative large firms become involved.
- High risk, high cost projects can be undertaken.
- Tremendous benefits are possible from the synergy produced.
- Non-market institutions often play a decisive role.
- Products resulting from co-operative R&D are likely to be well designed and to have multiple applications, fulfilling the aim of "design for all".

7. Complex International Agreements

This type of technology transfer mechanism is usually involved when companies undertake the development of low to medium technology products for a mass market. The huge production scale required, with the potential for profit that such a large market suggests, encourages companies to make the large initial investment. As a rule, the end products have highly standardised characteristics, and non-market institutions usually play an important role. The type of complex international agreements which we are considering as part of the technology transfer process usually involves huge investments in infrastructure, and might be brought into play when partners are considering the setting up a steel plant in a key location, for example. This type of technology transfer has very little to offer to the Rehabilitation Technology industry. The technologies usually involved in this type of transfer are wide-spread and mature, very expensive and difficult to improve upon, and have a high minimum production scale

8. Joint venture R&D agreements

In such agreements the technology involved is often at the leading edge of development, where the rate of technological change is very rapid and the required investments in R&D are substantial and the prospects uncertain. Joint venture R&D aims at understanding the basic principles that rule the technology and the products under development. These products need not be standardised, but their development often requires that they utilise complementary technologies. Companies that form joint venture R&D programmes, are usually both specialised and complementary to each other - each one brings its own strengths to the partnership. The actual extent of these complementary specialisations and their technological proximity define the synergies that can be created in the process of developing the products that will emanate from the joint venture. There is also (as in the case of co-operative research and development) a fair chance that products developed under joint venture R&D programmes will have multiple applications. This can be useful to the rehabilitation technology industry, as it can result in products that are "designed for all", rather than just to serve a specific subset of the population. Non-market institutions again have great potential importance as buyers or capital suppliers or co-ordinators, supporting the development of joint venture R&D programmes.

9. Joint ventures

This mechanism does not usually aim at the development of a specific product, but at keeping the parties involved informed of any developments at the technological frontier and at pushing these frontiers further back. The same comments that were made under the previous case, *Joint Venture R&D agreements* are applicable here.

10. Cross-licensing

With rapid technological change, high investment requirements, technological complementarity, and company specialisation, it would seem that cross-licensing in the Rehabilitation Technology industry would almost certainly create valuable synergies. It must be stressed, however, that cross-licensing on its own will lead to nothing, unless it is followed by some form of R&D. The potential role of non-market institutions in the cross-licensing process is great, especially where the companies involved are major ones with massive technological capabilities and industrial strength. Assuming that some R&D is carried out in conjunction with cross-licensing, products developed under this mechanism have a chance, albeit a small one, of addressing more than one subset of the Rehabilitation Technology industry.

11. Agreements between Large and Small firms

This type of agreement, which is widespread in some industries, but not in Assistive technology, represents a form of technology transfer management which differs significantly from those considered previously. The agreements may or may not involve the use of venture capital. The basis of such an agreement is that a company operating outside a particular sector, but wishing to enter it, decides to collaborate with a firm already working in that sector. The collaboration may involve several areas, including technology. The most usual form of such collaboration, which is seen as having the greatest potential for success, is where the firm outside the sector in question is large or medium sized, and where it has extensive international market links. The chosen partner firm, which already works within the sector in question, is usually a small firm, but one that is dynamic, and involved in high technologies or knowledge-based industry, working at the frontier of a specific technology or

domain. The large company benefits from the specialised and up to date knowledge of the small one, whereas the small company benefits from the market links which the larger firm has developed, and possibly gains access to a new source of finance.

For such agreements to succeed within the Assistive technology sector, the collaboration between the small, knowledge-based firm and the large firm will be need to be strengthened by the presence of a committed player (either a company or institution) who can ensure that end user needs are addressed adequately. This would have the added advantage of providing an ideal situation for the realisation of the "design for all" objectives. The role of non-market institutions (e.g. regional or national government, European Commission) in this area is expected to be of particular importance, since other incentives as well as specialist information may be required in order to attract large firms into the Assistive technology sector.

Table 1 summarises the various mechanisms which have been described. The vertical axis shows eleven different mechanisms for technology transfer. The horizontal axis contains six columns highlighting important factors, including an assessment of whether or not each particular technique is likely to lead to our "design for all" objective.

Assessment of technology transfer mechanisms

Mechanisms for technology transfer can be classified into two broad categories:

- Those mechanisms which involve transfer of technology mainly to technologically less knowledgeable companies. These involve a clearly predefined transfer of technology or know-how, but not necessarily a transfer of all the basic information underlying that technology. The result is that the company to whom the technology has been transferred will end up having all the information it needs to use that technology, but will not necessarily have an understanding of why a particular process or technology works the way it does.
- Those mechanisms which are mainly concerned with the transfer of technology to companies that are already technologically advanced. In this category, full transfer of technology is implicit, and this happens mainly through co-operation in the development of new products at the frontiers of technology. In addition to the transfer of know-how, the recipient company also gains a complete understanding of the technological basis of the development.

The higher the technological intensity of the product and the higher the level of technological capabilities of the firms involved, the greater the likelihood of encountering the mechanisms above. A point that may need some clarification is the fact that in some cases where all the right ingredients are present to suggest the use of a sophisticated mechanism for the transfer of technology, we do not always find it, some companies preferring to rely on more traditional transfer mechanisms such as licensing or technical support, etc.

As already mentioned, licensing, technical support and advice are less sophisticated tools, generally used by relatively less capable firms, and these techniques are often used more than one at a time. What is of interest, however, is to consider the very different implications of using the traditional mechanisms rather than the more sophisticated forms.

Consider, for instance, the use of licensing and its implications. Continuous licensing, especially when only one source is used, can have negative effects as well as the

expected positive ones. On the positive side, knowledge, whether in the form of documents, drawings, or computer files, or "know-how" and experience passed from one person to another, is easily transferable between the companies, and licensing such knowledge, in conjunction with the climate of trust created between the two parties, can form the basis for better co-operation and a more thorough technology transfer in the future. On the other hand, a long-term continuous relationship, especially with a single technology supplier, could mean that the recipient firm comes to depend too much on that supplier and loses the capability to carry out future technological activities on its own. This dependency effectively means that the terms under which technology is transferred become less than optimum, as there are considerable restrictions and obligations for the recipient, who has less than unobstructed access to the transferred technology. In the most severe cases, if the supplier wants to extend his trading activities, then the recipient may even degenerate to the level of effectively becoming merely a local representative of the supplier, simply purchasing the technology and assembling the parts he is being sent, without the slightest chance of understanding or changing the technology. Licensing could therefore take several forms. One could be the transfer of technology in the sense of a deep knowledge of the technology of the merchandise; a better scheme could provide sufficient knowledge to lay sound foundations for future improvements and modifications or even radical changes to the technology, whilst a third option may amount to little more than the simple purchase of a technology, as described in the previous paragraph.

From the above arguments, it follows that learning by doing, although quite useful, is not sufficient and usually leads to dependency and a state of permanent infancy, especially at a time when technologies are complex and their development takes place in a well organised environment of intra or inter-firm research and development. The above argument implies that if the recipient firm is to ever develop autonomously in the future, then it will have to be capable of understanding and internalising the basic technology, and in order to do so, it will have to develop its technological capability and of course, be able to carry out research and development on its own.

The technology transfer mechanisms described above certainly exist, so the fact that Assistive technology firms have not used these mechanisms, or have done so very sparingly, could be interpreted as either a refusal to do so or inability to do so. There are a number of very important reasons why firms are facing serious difficulties with technology transfers.

First of all, firms in the Assistive technology industry are generally small and very small, and do not undertake research and development, a situation which does not encourage either the search for new products or the desire to collaborate. For those small, but dynamic, knowledge-based firms who do want to search for new technologies and to collaborate with others, their small size and lack of research and development are serious impediments.

Secondly, acceptance of technology has different thresholds for different uses, and in the case of Assistive technology products the demands on users are rather high. Firms sharing the characteristics of those in the Assistive technology industry also face serious problems with information flows. Any technology transfer has to address a number of issues connected with information flows, such as awareness, interest, evaluation, trial, and adoption, which in turn necessitate the types of network mechanism proposed earlier, to establish the infrastructure for innovation and technology transfer.

From all the above arguments, it is clear that there is nothing automatic about technology transfer and that there is no reason for it to happen unless somebody or something originates it. Non-market institutions could therefore play a decisive role.

Finally, it should be repeated that the greater the difference in technological capability between the source and the recipient, the more difficult successful technology transfer will be. Above a certain threshold of difference, no transfer will be possible.

Conclusions

The paper has reviewed the conditions, from the general to the more specific, that are needed for successful technology transfers to take place towards the AT industry. In addition, it has investigated, a number of existing mechanism for transferring technology from one place to another. The discussion has revealed that in the context of Assistive Technology, such transfers will be very difficult to achieve. Still, there are more issues to be addressed. The decision-making process could be further decomposed for there are still questions such as what product types are needed on the market, how could they be produced, through which technologies, and what other characteristics should the envisaged technologies exhibit. In other words, questions which by their strategic nature and given the present state of the firms in the AT industry, cannot be envisaged or faced at that level. To put it simply, there is a need for a body to access needs, evaluate potential sources of transfers of technologies on the basis of their merits, impact, repercussions and synergies and to co-ordinate sources and recipients, or at least to provide the minimum "infrastructure" for such transfers to materialise, or provide basic incentives to do so.

For, it should be kept in mind, that even with all the reservations expounded upon at length, there is the additional problem that small firms are not very likely to come forward requesting collaboration, and in fact are known not to do so. Besides, if we are interested in the development of the AT industry throughout the member states and not just the AT industry irrespectively of location, then there is an additional parameter to be taken into consideration. When it comes to collaboration, firms behave very differently in the developed countries as opposed to developing or less developed countries. In developed countries, firms tend to seek collaboration in order to solve some strategic long term problem while in developing countries their behaviour is much less sophisticated. Strong evidence of this is provided in the survey cited earlier covering firms in the U.K., Spain and Greece, where it was found that firms in the U.K. behaved in a way totally different than the firms in the other two countries.

Finally, there are still more issues to be considered, issues pertaining to higher order conditions dealing with creating a favourable environment. Such issues pertain to wider items whose effect would be felt throughout the AT industry and would affect most of its activities including transfer of technology. These issues include policy variables such as standardisation, legislation, regulation, etc. Each of course, is a subject to be investigated alone on its own merits. We simply mention them here for the sake of the completeness of our arguments.

Now, let us suppose that all of our conditions raised so far have been met. Should our conditions still be treated as necessary but not sufficient. The answer is in the affirmative for, as Schumpeter repeatedly insisted "entrepreneurship is the direct cause; the economic environment can only create favourable conditions".

From the discussion thus far, a number of conclusions may be drawn. First of all, it has become evident that there is a definite need for non-market organisations, since technology transfer towards the European Assistive Technology industry will not take generally take place without assistance. Moreover, if help is to be provided, it should be limited to companies which are committed to the Assistive technology sector and willing to perform serious research and development. Learning by doing, without research and development, is a recipe for failure.

There could be advantages in providing help to bring together partners for collaboration and technology transfer. Large firms outside the Assistive technology sector, and the few large firms present within the sector but not committed to it should be introduced to:

- firms that are committed to Assistive technology, which have research and development, and some technological capability;
- assistive technology SMEs, working at the technological frontiers, with detailed knowledge of the emerging technologies.

"Design for all" should be the aim of all emerging technologies. The newer a technology, the greater are the chances of being able to achieve design for all. However, for such condition to materialise, a monitoring system for critical emerging technologies should be established. This monitoring system, which could be part of an extensive collaborative network, should aim to identify potential synergies and possibilities for collaborative research and development.

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Table 1: Summary and assessment of mechanisms for technology

Mechanisms of technology transfer	Level of the technology involved	Size & technological capabilities of firms involved	Role of non-market institutions	Nature and characte
1. Licensing	High or Medium or Low	Source usually larger than recipient in size and technological capabilities	Important in the case of assistive technology	Non-stand depends on th without techn
2.Patent (purchasing)	Usually high	The purchaser is usually the larger firm	Important only as supplier of funds	Non-standa cor
3.Technical advice	High or Medium	As in 1	As in 1	
4.Technical support	Same as above	Same as above	Same as above	S
5. Contract R&D	High Medium	The recipient is usually large or at least medium sized SME	In general not important but important in the case of RT	Not necessari strong exister
6. Co-operative R&D	High	Both source and recipient are very large	Very important (co-operation with governments and universities)	Strongly sta signifi com
7. Complex international agreements (Not applicable in RT)	Medium	Source very large	Important in LDCs but limited in advanced countries	
8. Joint venture R&D agreements	High	Large firm, international oligopolist	Large purchaser and/or supplier of R&D funds	Not very stan technologi
9. Joint ventures that aim at keeping partners informed	Same as above	Same as above	Same as above	S
10. Cross-licensing (referring to separate product markets)	High	Oligopoly	Usually not important but important in the case of RT	Technological special s
11. Large-Small firm agreements	High and rapidly changing, evolving technology on the basis of oncoming techno-economic paradigm	The small firm is knowledge intensive	Very important for the case of RT	S