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TRANSFER PROCESSES IN TECHNICAL CHANGE

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THEORIES OF TECHNOLOGY TRANSFER, OR. MODELS, IMAGES, AND MYTHS REVISITED

by *R.D. Johnston**

Introduction

In this paper it is intended to critically examine the progress made in the study of technology transfer, though not in the traditional way by reviewing the findings of various research projects; this task has been most adequately carried out by a number of people e.g. Douds, [1]; Chakrabarti, [2] and Bradbury [3]. Rather, it is the intention to focus on some of the theoretical and conceptual assumptions which have underlain much of this research. As a result, this paper is directed primarily to those engaged in the study of the phenomenon of technology transfer but, at the same time, it should be of considerable relevance, both immediately and in the longer term, for those engaged in the practical business of effecting and promoting the process.

Examination of the literature reveals that a wide range of activities are included under the label of technology transfer. Which immediately leads us to our first problem; that of definition. Technology transfer is such an umbrella term that it has become even more "de rigeur" than usual to define the particular connotation being used. Thus for Gruber and Marquis "The transfer of technology must then mean the utilization of our existing technique in an instance where it has not previously been used" [4]; for Chakrabarti "Technology transfer can be viewed as the generalized process of information transfer between science, technology and actual utilization." [2] and for Brooks "Wherever systematic rational knowledge developed by one group or institution is embodied in a way of doing things by other institutions or groups, we have technology transfer" [5]. However, for our purposes, what is most important is that we do not get bogged down in argument over the precise definition of the term. Rather we should recognise that at the most fundamental level we are dealing with the movement of

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knowledge across interfaces, while keeping in mind that there may be important distinctions between specific sub-elements within such a general framework.

To those who are familiar with the technology transfer literature, the subsidiary title of this paper will recall the contribution of Tom Burns to the 1966 M.I.T. Conference on the Human Factor in the Transfer of Technology, subsequently published in 1969 in the conference proceedings [6]. To some it may appear indecently hasty to be engaged so soon in the academic pursuit of "revisiting". However, Burns' article can be considered to have marked a watershed in studies of technology transfer. His conclusion that "the mechanism of technology transfer is one of agents, not agencies; of the movement of people among establishments, rather than of the routing of information through communication systems", marked a considerable step forward in understanding of the technology transfer process. But instead of this recognition of the importance of people in the movement of information providing a stimulus to a new generation of research [7] it has atrophied into a slogan trumpeted, without added insight, in most studies since that date. As a consequence the major problems raised by Burns have been both neglected and misunderstood.

It is the contention of this author that by re-examining the Burns' argument and developing it along a number of dimensions a basis may be provided for escape from the present doldrum state of technology transfer studies. In particular this critique is developed along just two major lines, one concerned with the state and function of knowledge in our industrial (or post-industrial) society, and the other with the nature and organisational environment of technology in that same society.

Prevailing Assumptions in Technology Transfer

One of the general assumptions underlying much study of and attempts to expedite technology transfer has been that there is some real or reified object or "package". which is to be transferred. The very verb "transfer" implies the movement of an object. To conceptualise technology as an object is to stumble into the methodological pitfall of over-reification of a concept. One consequence of this assumption has been the adoption of a "black-box" approach to technology transfer whereby the process itself is consigned to the mysterious or unknowable and research is concentrated on the inputs to and outputs from the box. Thus there have been many studies of organisational characteristics and the impact

of various management styles on technology transfer and innovation and on this basis prescriptions for success have been made. Similarly, at the individual level sociological and psychological factors such as social status, "cosmopoliteness" and achievement orientation have been related to success in securing the transfer of technology. While outputs have been the subject of less detailed study, the assumption behind many studies has been that success in technology transfer leads to success for the firm and for the national economy.

This reification of the concept of technology may be a consequence of the common identification of technology with hardware. However, to consider technology simply as a collection of artefacts is to make the same kind of mistake as that of the bibliometricians of science who have confused the scientific body of knowledge with the explicit content of scientific papers. Technology is not a body of systematised knowledge in the same way as science because the goals of the two forms of knowledge are different. Nevertheless, while there is little conscious effort on the part of the technologist to systematise his knowledge, it is apparent that when confronted with a problem, he does not search for potential solutions on the basis of first principles. He has a set of guiding rules composed of sets of elements of scientific law, technological "knowhow" and previous practice or which to draw. It is the essence of these guiding rules or principles which form the basis for treating technology as a system of knowledge [8].

This emphasis on technology as a knowledge system is not intended to suggest that an understanding of the function of such commercial devices as patents and licences is of no importance. However if we are seeking to gain a clearer picture of the mechanisms and roles of technology transfer at the national level, we need to probe for an underlying structure which will provide us with a knowledge basis to control and direct the production, diffusion, adaption and infiltration of technology more effectively.

Another assumption implicit in many technology transfer studies appears to be that the process is immutable and ahistorical i.e. that there exists a single most effective way of transferring technology, independent of such factors as the type of technology, environment, or cultural milieu. Some studies, such as those by Burns and Stalker [9] have examined the organisational structure appropriate to different forms of technology. Nevertheless in general, technology transfer has been examined without attention to the changing nature and role of technology in modern society. It

would seem a reasonable hypothesis that the process is considerably different today to what it was twenty years ago. Similarly, just as it is now recognised that technology embodies both economic and cultural elements that may not make it appropriate for all societies, so it is possible that the process of translation of knowledge across interfaces may also vary from one environment to another.

One other common assumption is that any action or policy which increases or improves technology transfer is automatically good. As the application of technology to problems different to the one for which it is conceived leads to innovation, so the more technology transfer, the more innovation, and presumably the greater the public good. Such an assumption needs rather close examination for at the very least it might be expected that the volume and effectiveness of previous transfer affects subsequent performance.

The Structure of Knowledge in Modern Society

The first general theme I wish to examine for its relevance to the phenomena of technology transfer is the structure of knowledge in our present Western society. If there have been radical changes in the form or function of our knowledge systems, one might expect there to be corresponding changes in the process of technology transfer.

It is not startlingly novel to state that we live in a knowledge-oriented society. Such crystal-ball gazers as John Kenneth Galbraith [10] and Daniel Bell [11] have emphasised the growing importance of theoretical knowledge in the operation of the modern state. While their case may be somewhat exaggerated there can be little doubt that an ever expanding body of systematised knowledge has become an essential requisite for the kinds of economic growth we have observed in the last two decades. But what are the consequences for science and technology of being in such a situation of demand?

Here perhaps we can turn to sociology for some insight. When a particular activity is recognised as having a functional value in society it becomes institutionalised. Included in this process will normally be growth, increasing control on entry, development of accepted norms of behaviour for those within the institutions and the emergence of a career and possibly professional structure.

This is an extremely crude and mechanistic model which is capable of much more thorough development. However, it may be

sufficient to provide us with some useful tools for the analysis of the structure of knowledge system today. For the very demand and support for science and technology has led to its institutionalisation. Further, if we accept that the neccessary response to growth in any organisation is segmentation, then the growth of organised knowledge in response to demand has resulted in the development of a large number of relatively isolated knowledge divisions. Thus with the very success in producing knowledge, there has developed an institutional structure which divides and separates fields from one another. Furthermore each knowledge field becomes increasingly isolated from the practical problems which served as its initial focus, and concentrates on problems generated according to its own internal dynamic.

If to this argument we add the theories of Kuhn [12] and his supporters who have argued that the remarkable progress by science, and I would claim this holds equally for technology, is based on the acceptance by groups of researchers in a field of a paradigm – an accepted set of practices, models and theories which determine both problems and solutions – then we have an explanation of the structure of knowledge in modern society. While we have more knowledge, or at least information, available than at any time in our history the processes of institutionalisation and specialisation have made it less comprehendable and hence less freely available to those outside each field.

Here then is a paradox. The very system necessary for the effective growth of knowledge at the same time serves to build barriers around that knowledge and isolate it from its potential application in other areas. But technology transfer does occur, so how is it achieved? While the barriers are real, they are neither as insurmountable nor as inevitable as perhaps suggested above. Turning again to sociologists' study of science, we see that developments within a field themselves challenge the boundaries. A discovery can lead to a change of focus. At such a period of restructuring the barriers are low and movement of people and ideas into and out of a field is easier. Thus there is a continual dialectic tension between the setting of constraints around a field in order that it may progress, and the breaking down of the constraints in order to provide the basis for further progress.

The first lesson with regard to technology transfer then is that it is inherently difficult; resistance to the movement of technology is not a result of bad management or sheer perversity. The value of mobility is demonstrated – this is the origin of the "agents, not agencies" argument – but placed in context it can be seen that the

movement must be tied in with levels of development in appropriate knowledge fields. Future research in technology transfer should include a consideration of such factors as cognitive development and examine whether the detection of indicators of barrier breakdown is possible.

The Organisational Environment of Technology

The second major theme which it is necessary to develop is concerned with the organisational environment of technology. Just as studies of technology transfer have to a large extent ignored the institutionalised structure of knowledge in today's society, so they have failed to consider the changing nature of the environment in which technology is primarily produced and transferred i.e. industry.

This oversight cannot be attributed to a lack of information about the structure of industry today. Any number of books have been written on the growth of multi-national corporations and the power they have to manipulate the environments in which they operate to their own advantage, ensuring their supply of raw materials by participation in extractive industries, choosing their manufacturing sites on the basis of a wide range of factors including tax structures, and wages and transport costs and finally marketing the same product in many different countries.

Associated with but distinct from the emergence of the multinational firm has been the growth of conglomerate companies, engaged in highly diversified, but mutually supporting industries. The single-product company is increasingly uncompetitive. Let us examine the business of steel-making as an example. Problems of availability of iron ore have led companies to invest in exploration and mining. The fact that this ore is increasingly located distant from European mills has led to an involvement in transport and in the construction of bulk ore carriers. The high consumption of oxygen in a modern steel plant has resulted in an involvement in industrial gas production. Developments in special purpose steels requires an availability and knowledge of non-ferrous minerals. The competition of substitutes such as aluminium and plastics have led many traditional steel companies to diversify into a general material business. Pollution legislation has required the more careful treatment of effluent leading to for example the construction of sulphuric acid plants for converting trapped sulphur dioxide. All this excludes expanded information processing, financial and marketing services involving completely new areas of competence.

Yet another development has been the growing involvement of government in industrial activities in the so-called "mixed economy" of modern capitalist societies. This ranges from the provision of relatively small-scale risk capital, as by the N.R.D.C., to the massive backing of high-technology, as in the aerospace sector, to the influence of government legislation on pollution and safety, and to the projection of government agency generated knowledge into the private sector. Also the nationalised industries are following the conglomerate trend by becoming involved in a range of activities which may be considered a spin-off from their initial concern.

I am not suggesting that there are not still a lot of small single-business companies. However, if we are interested in technology transfer and its impact at the level of the national economy, then it is in the environment described above that we must examine it. What then are the consequences of this industrial environment for technology transfer?

The first of these refers back to the assumption that with respect to technology transfer, more is automatically better. In the modern corporation there is a complex variety of factors which must be taken into consideration in the making of any decision, including that to seek or adapt new technology. Thus in the case of the steel company, the decision to diversify into plastics is a consequence of an analysis of market trends, raw material availability and cost, capital investment and likely return, technology, spare capacity, etc. There may frequently be very good reasons for deciding not to become involved in a new technology. What is needed from technology transfer studies is a careful examination of the conditions under which a company seeks new technology as there are far more important controlling factors than the availability of technology.

The process of integration and rationalisation which has occurred in industry should apparently reduce the barriers to technology transfer, as the interfaces between the various activities in which different technology is employed should be reduced. Similarly the growing involvement of government in industry should provide increased opportunities for technology transfer. There is some evidence to suggest this has actually occurred. However there is considerable scope for examination of just how technology does get transmitted in such an environment and whether sufficient attention is paid to the technological element in the process of rationalisation and diversification.

The Social Climate for Technology Transfer

No discussion pertaining to technology today would be complete without a reference to the growing unease and resentment towards technology being expressed by considerable sections of the public. To this date there has been no widespread rejection of the products of technology and it is difficult to conceive how such a rejection could occur in a society so heavily dependent on technology. Nevertheless there could be increasing resistance to the development of certain forms of technology and any comprehensive theory of technology transfer should allow for this possibility.

A considerable limitation of studies of technology transfer as previously mentioned is their acceptance of the "more is better" argument without any consideration of the ultimate purpose of the technology. Therefore one would welcome the inclusion of some form of assessment into these studies. While the growing bandwaggon of technology assessment is hardly likely to provide a panacea for technological and other social ills, there seems to be every case for including an analysis of why certain technologies should be sought, or adopted, not only with regard to the economic basis for the firm but also in terms of social value for the ultimate adopters.

Conclusion

Much of what has been argued may appear obvious but the fact remains that both studies of and programmes to foster technology transfer have been based on narrowly conceived assumptions which bear more relationship to the economist's idealised conception of perfect competition than to the actual structure of both industry and knowledge in a modern industrial society.

If research on technology transfer is to be of more use and have a greater impact on those involved in its implementation, it must be situated in a real-world environment. Two features of present day society have been developed, and a third briefly mentioned, which are of major importance in analysing the process of technology transfer. In particular, studies of this phenomenon must pay close attention to the structure of the knowledge system from which and to which transfer is occurring and also the nature of the organisational environment within which it takes place.

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