A PERSPECTIVE ON TECHNOLOGY

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SUMMARY

It is a part of engineering training that one approaches any problem by first defining it properly, and by ensuring that there is no ambiguity in the units or terms to be used. It is unsatisfactory to find that the term 'technology' is used to take almost any meaning that the user wishes to convey. The term has acquired wide currency and is accorded considerable importance by commentators of every persuasion. The disagreement and controversy over the use and abuse of technology owes much to mutual misunderstanding of the concept of technology. This paper discusses some aspects of the definition of technology, the relationship between science and technology, the approach of economists to technology, and the international (and hence inter-cultural) transfer of technology.

1. INTRODUCTION

There can be few people in the English-speaking world who are not acquainted with the word 'technology'. In its absolute form, in a qualified form or as a derivative, it is a word that occurs commonly in the media and in everyday conversation. Despite its familiarity however, it is apparent that the concept attached to 'technology' varies widely between different people.

Irrespective of the various interpretations that are put on the word technology, there remains an overwhelming agreement on its importance to modern industrial society. Whether the influence of technology is malevolent or benevolent, it is seen as being the prime mover in economic development to such an extent that updating indigenous technology is considered to be a necessary precursor to economic growth.

Controversy and misunderstanding exist over the most effective means of promoting technological development, largely because different people attach different meanings to 'technology', and they are consequently trying to promote different ends. Until the elements that are part of technology are defined, it will remain impossible to ensure that policies designed to stimulate technological development are influencing it at all.

2. TECHNOLOGY: THE CONCEPT

The modern usage of the word technology owes much ot its derivation, although current dictionary definitions may seem to deny it. The 'typical' dictionary definition takes the form "science of the industrial arts; practical arts collectively; terminology of particular art or subject" (1). The appearance of the word 'art' (or arts) in each of the versions owes much to the etymology of the word in that it derives from the Greek work 'techne' which is simply translated as 'art'. This bland translation overlooks much of the subtlety of the use of 'techne' by the Greeks. In his "Nichomachean Ethics", Aristotle (2) chose to define techne (translated as art) as follows:

> *"Making and doing are quite different activities. Consequently the rational faculty exercised in doing is quite distinct from that which is exercised in making. Moreover, they are mutually exclusive, for doing never takes the form of making, nor making of doing. Take architecture. It is an art, that is a rational faculty exercised in making something. In fact there is*

> *no art which cannot be so described, nor is there any faculty of the kind that is not an art. It follows that an art is nothing more or less than a productive quality exercised in combination with true reason. The business of every art is to bring something into existence, and the practice of an art involves the study of how to bring into existence something which is capable of having such an existence and has its efficient cause in the maker and not in itself." (p175)*

Before leaving Aristotle, it is as well to acknowledge that in his terms,

> *".... we must admit that practical wisdom (Phronesis) is not the same as science. Nor, we must admit, as art. It is not science, because conduct is variable, and it is not art, because doing and making are different in kind, since the maker of a thing has a different end in view than just making it, whereas in doing something the end can only be the doing of it well. We are left then with our definition: Practical wisdom is a rational faculty exercised for the attainment of truth in things that are humanly good or bad". (p177).*

Hence, by derivation, technology is related to making or productiv activities, and the important point is that, in these terms, technology is directed at production rather than simply at action.

If one of the dictionary versions of the definition is examined more closely, it can be seen that 'science of the industrial arts' can be expanded to read 'the systematic and formulated knowledge of human skills in any branch of trade or manufacture'. Clearly this definition includes what may be called 'know how', which is certainly a necessary part of technology, but is it sufficient as a definition of technology?

Alvin Toffler comments that "To most people, the term technology conjures up images of smoky steel mills and clanking machines", and he goes on to say, "technology includes techniques as well as the

machines that may or may not be necessary to apply them" (3). In other words, although the expanded dictionary definition is accurate as far as it goes, it is inadequate in that it excludes the physical manifestations of the technology, i.e. the machines, tools and equipment that may be involved. This view reflects the opinions of most commentators writing about technology nowadays, though many of them go further still and include in technology".... everything which assists man to live in, compensate for, influence, pollute or destroy his environment." (4).

Part of the problem of defining technology results from a disagreement over the relationship between technology and technique. Implicit in most definitions is the assumption that any activity that can sensibly be thought of in terms of techniques constitutes part of a technology. In Nicholas Berdayaev's terms, "Technique seeks to attain in everything the greatest results with the minimum expenditure of power; such is especially the technique of our mechanical, economic age." (5). Berdayaev is prepared to accept the consequences of popular usage, and recognises techniques of "thought, versification, painting, dancing, law" for example. Although it is normal to talk in terms of techniques for these activities, they would not normally be considered 'technological'. Hence, there is no necessary correlation between technique and technology in general use. The essential difference is perhaps that technique implies a transitional state. Technique is active, it is the performance of an activity in a specific way. In fact it is the way that it is carried out. Technology on the other hand is passive. Technology is a state of capacity to act to achieve a desired end. It is by definition a body of knowledge or know-how (at least in part).

Clearly technique and technology are not entirely separate, for many techniques are essential parts of particular technologies. The normal way of relating them is by their motivation. This is the point of the reference to Aristotle earlier, although "Phronesis" is normally translated as "Practical Wisdom", it relates closer to 'prudence' than to empirical knowledge. It may be equated with selection of the correct technique for doing what requires to be done and for doing it well. To emphasise Aristotle's point again, what we call techniques for doing, must be treated as being different from what we call techniques for making. Techniques for making form part of technology: techniques for doing, do not.

The point of this distinction is that technology must be seen as being purposive. It is directed at attaining a desired end, which is not simply an end in itself, but entails some form of transformation.

3. SCIENCE AND TECHNOLOGY

There is a wide range of opinion on the relationship between science and technology, and particularly the knowledge aspects of technology. To many authors, technology is a sub-set of science. Singer, for example, writes, "To use it seems that science is the source, the parent, of technology"(6), and in a similar vein, Pirsig writes, "Science and its offspring, technology" (7). The relationship is the same, and it is this view that has been given 'official' recognition through its adoption by most government offices. This has resulted in the governmental approach to technological development being directed through the financing of 'scientific' research. The logic, of course, is that technology cannot progress without better understanding of underlying principles, and this understanding can only be obtained through scientific research.

At the other end of the scale, an equally large number of commentators hold that science is a sub-set of technology. Watkins and Meador, for example, state that "Engineering is a major branch of technology .... Science is another branch of technology"(8). Edwin T. Layton is rather more precise when he states, "... it was not until the 19th century that technology acquired a 'scientific content'"(9).

Between these two poles, there are those who believe that there is no significant difference between science and technology. Otto Mayr exemplifies this view in stating that "It is becoming clear, then, that a practically usable criterion for making sharp and neat distinctions between science and technology simply does not exist. If this is true, it follows that technology and science are not mutually exclusive"(10). Whilst many authors have encountered the same difficulty in precisely defining the differences, a few are prepared like Mayr to accept that technology and science are therefore the same thing. Alexander Koyre expresses the more normal view "... that although they are different, there is common ground between them"(11). In other words, in the Venn diagrams of logic, the system boundaries of science and technology overlap, so that there are common aspects and mutually exclusive aspects(1).

(1) *Note that in the second quotation from Aristotle, he maintains an essential difference between art (techne), practical wisdom (phronesis) and science.*

There is a further viewpoint, propounded forcibly by Michael Fores (12) for example, which holds that technology is the same thing as industrial engineering. This however only seems to create further difficulties, because it adds a third dimension to the problem. If it is assumed that because it is difficult to differentiate between technology and industrial engineering, then they are the same thing, then one questions how it has come to be acceptable to use the words differently in practice. Universities seem to have little difficulty in establishing suitable and different curricula for courses in Industrial Engineering, Industrial Science and Industrial Technology, for example, so they must feel that there is a substantive difference between them as disciplines.

4. TECHNOLOGY AND THE ECONOMISTS

It is a common myth amongst Economists that they understand technology. It is maintained that technology and, in particular, technological change has been explained in economic theory by the concept of a production function (13). This function represents the complete range of technologies available at any one time by means of a simple two-factor analysis often represented in an isoquant diagram. Essentially, the theory assumes that every technology can be represented by a unique combination of 'Labour' and 'Capital'. The many different possible combinations of labour and capital, which define the possible production technologies, may be graphically represented, and the most efficient of these combinations will describe a curve which defines the 'technological frontier'.

There are many definitional problems with this theory, and even more operational ones, but the theory is inherently reasonable. Although there may be no direct links with Marx's (14) work, it is obvious how strong the relationship is between the two-factor production function, and Marx's theory of 'Added-Value'. Production is accomplished by certain proportions of labour and capital being brought to bear to effect the desired transformation of the materials; similarly value is added by the transformation induced in the materials being effected by the 'addition' or creation of value by human labour, and also by the transfer of value from the machinery or capital.

This theory of production seems adequate, until it is applied to the real world. The economists equate all commercial 'techniques' with 'technology', and this is the reason for the lack of fit of their theory with practice. Technique is an absolute term, and describes the way something may be done. A 'good' technique describes

the way in which an activity of function may be performed well. If the technique is effective in location 'A' it will be effective at any other location 'B', since it is the state of transition that 'technique' defines. Wherever it may occur, if hammer h, hits nail n, into the wood, w, satisfactorily, the technique may be considered effective or good. If however, hammer h, hits thumb, t, the technique is bad.

On the other hand, (if you will pardon the expression), technology stands in a much more complex relationship with its environment. Whereas technique is transitional or active, technology is passive, or is a state of capacity to act. Technique requires only consideration of those factors which directly influence or affect the conduct of the activity; technology requires consideration of a wider set of factors which include all circumstances and relationships which may affect or condition the whole proposed process of manufacture. In Robert M. Pirsig's fascinating book "Zen and the Art of Motorcycle Maintenance", there is a statement which perfectly illustrates this qualitative difference. Pirsig records an introductory statement from a 'technical' instruction manual which reads: "Assembly of Japanese bicycle require great peace of mind" (7). By no means could this be considered a 'technical' instruction in the normal sense of the word, i.e. it is not related to the technique of the assembly process. It is however an important factor in the technology of the overall process, because it is a factor that can affect or condition the conduct of the assembly procedure.

Technology, which may be defined as 'the reasoned state of capacity to make', obviously does not 'grow on trees'. It has to be developed, by the accumulation of knowledge and reasoning, and by the gathering together of the materials and artefacts necessary to put it into effect. This is not to say that it is restricted to being a human attribute. There is no philosophical reason why an animal may not be considered to be able to act 'technologically'. In other words a nest may be considered a technological feat for a bird, and in particular, there seems no reason why a chimpanzee should not be considered a technologist when he performs quite complicated tasks in order to get food, and especially when he copies technological man to do so. Efforts have been made to justify certain events in the history of man as marking the first application of technology. Such efforts have been unconvincing, as they have failed to distinguish satisfactorily between the states of "non-technology" and "technology.

5. TECHNOLOGY TRANSFER

As has been stated earlier, whilst the basic definition of technology limits it to a body of 'systematic and formulated knowledge' this goes counter to normal understanding and usage. Indeed for many years, when international agencies discussed the exchange of 'technology', they were referring specifically and only to pieces of machinery. It was only when countries began to find that 'technology' is not a lump of machinery that can be moved from one location to another, that effective technology exchange became possible. The United Nations Conference on Trade and Development (UNCTAD) in 1972, proposed a new definition of technology for their own purposes. Technology is to be considered "an essential input for production. Technology is to be bought and sold as:

1. Capital Goods, including machinery, and productive systems.

2. Human Labour, usually skilled manpower and management, specialised scientists.

3. Information, of both a technical and a commercial character, including that which is readily available and that subject to proprietary rights and restrictions"(15).

The impetus for such agencies to seek to define and understand technology was given by the economists' insistence on the high correlation between industrialisation and economic development. It is taken as being self-evident that economic development (and hence industrialisation) is a desirable thing, and indeed is the inevitable course of public policy. The ready acceptance of this precept is a sad indictment of the cultural values of many politicians. Industrialisation requires the adoption of 'industrial technology', as it has been called. In order to achieve the desired rapid industrialisation, it has generally been deemed necessary to purchase and import the required 'technology'. There can be little doubt that this process of acquisition has often had very unsatisfactory results.

The reason for this lack of success has often been given as the conflict of interests between the 'owners' of the technology (Multi-National Enterprises), and those seeking the technology (Less Developed Countries). There is no doubt that this conflict of interests has led to many contractual problems; however, at a more fundamental level, what is often overlooked is the misunderstanding over what is meant by 'technology'.

As mentioned above, international agencies like UNCTAD, since about 1972, have recognised that technology is multi-faceted, in as much as it is production oriented. The successful conduct of production requires more than the appropriate equipment, it requires also the appropriate infrastructure. The infrastructure here includes the necessary operational skills, managerial capabilities, and general information in the form of performance specifications, as well as the physical infrastructure in the form of transport facilities, water, power, etc. There is a further aspect of the necessary infrastructure that is often overlooked, and that is the cultural aspect.

Technology develops as a result of the intervention of an agency, and for human purposes that agency is man himself. Man is a social animal. A number of separate societies have developed, primarily as a result of geographical partitioning, and these societies show a variety of cultural developments. It is because of the dissimilarity between cultures that different societies exhibit not only different stages in technological development, but the technologies themselves differ. This is the crux of the matter. Technology is socially and culturally conditioned, and it is an inescapable consequence that a technology removed from one context will fit uneasily into another.

It is not the intention in this paper to fully discuss the cultural aspects of technology, but rather to draw attention to their existence. Nevertheless, it is perhaps necessary to mention a number of cultural factors which could seriously affect the 'appropriateness' of a technology in a different social environment. Firstly, in most societies there are very strong patterns of labour established. The patterns are generally of a local character and reflect not only such 'intangibles' as the job preferences of the individuals, but also the need for duality in employment (particularly where one of the jobs is in subsistence agriculture, as in crofting in Scotland), and the seasonality of many forms of employment as well as other factors including of course both sexual and historial prejudice against certain types of employment. (These latter factors cannot be overlooked in societies like those in the Caribbean where the less-educated majority of the population put such great stress on male masculinity or 'macho'. This creates sexual prejudices against certain forms of work which, for example, may be considered demeaning to the 'macho' man. There is a good example of 'historical prejudice' in the Caribbean also,which derives from reaction to historical slavery. The reaction is demonstrated by the antipathy felt by many West Indians of African descent to any form of agricultural work, and especially towards work in sugar cane or cotton fields). Finally, it should be recognised that culture conditions the prevailing attitudes to work, and these attitudes are usually represented by what is called the 'work ethic' of the population. Technology

which is imported must either take account of the local work ethic, or social changes have to be instituted to alter the indigenous culture as regards attitudes to work.

6. CONCLUSION

Because the word 'technology' is used sloppily to take any meaning that suits the user, it is not surprising that considerable controversy surrounds it. It is in one context described as the only hope for mankind, and in another as the ultimate representation of all that is evil in man's dealings with his environment. The view adopted reflects the objectives and values of the commentator, rather than anything inherent in the technology.

Attempts have been made in many countries to initiate economic development by importing 'technology'. The fact that so few have proved successful is due largely to a misunderstanding of the full implications of technology, and in particular the failure to recognise the cultural aspects of technology. The transfers of a man, a machine and a piece of paper, although better than the simple transfer of a machine, are not sufficient to ensure that the particular 'technology' will be successfully transposed. Further work is required to determine how a technology may be adapted to take account of cultural factors in its new environment.

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