The Economic Journal of Nepal, Vol.16, No.2, Issue 62, April-June 1993 © DOE-TU

Promoting Technological Capability in Developing Countries

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INTRODUCTION

Until the late 1970s development literature and research concentrated their attention on the choice of technology, and the terms of transfer from the North to the South. Science has played a very important role in the growth of world production is now an established fact. Studies conducted in the USA on the growth of productivity have shown convincingly that as much as three quarters of the modern growth of the economy are due to increased efficiency in the use of productive inputs and not to the growth in the quantity of resource inputs per Se, (Metcalfe, 1987). The significant contribution made by the *residual* factor demonstrates the part played by science and technology through research and development (R&D), technology invention and absorption. A major weakness of this work was that to a great extent it ignored the questions of how the technologies could best be introduced to the economies of the developing countries. The important issues of how to best adopt the imported technologies and how the knowledge arising from import and export could best be diffused through the economy were not addressed. Also later studies concentrating on the trade and industrial policies, joining the debate on import-substituting versus export-oriented strategies, focused their attention on incentives, rather than on the structural factors such as the labour and capital markets, education system, management system and skill, innovation, research and development. However, in studies of developed countries these structural factors were recognised as significant constraints in the building up of industrial competitiveness. Recently, research based on the industrial experiences of the NICs has also taken these aspects into consideration, and has contributed to the development of a new framework for understanding the industrial performance of developing countries. (Dahlman et.al, 1987; Lall,1987; Enos and Park, 1989).

TECHNOLOGICAL CAPABILITY: ECONOMISTS' VIEWPOINTS

In *The Wealth of Nations* , published in 1776 Adam Smith drew attention to the importance of technological progress, facilitated by division of labour, as a means of increased productivity. Improvements in methods of production resulted from invention both by the workers themselves and by *Philosophers* - specialists in science and technology (Smith,1982). Joseph Schumpeter, who was a great believer in the role played by entrepreneurs, also emphasised, especially in his later works, the role played by the departments of large companies enabling the move towards new technology. It was the need for companies to compete and be ahead of one another that prompted entrepreneurs to be constantly looking for innovation that would lead to further

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technological progress. In the words of Schumpeter, "Any existing structures and all the conditions of doing business are always in the process of technical change. . . In order to escape being undersold, every firm is in the end compelled to follow suit, to invest in its turn and, in order to be able to do so, to plough back part of its profits." (Schumpeter, 1983).

Recent developments in electronics technology are making people more and more conscious about the great contribution that technology can make. Indeed, the global economy is experiencing a multi-focused period of technological change in which the dominant feature is the growing science-content in technology. (Cooper and Kaplinsky, 1989). However,for developing countries the use and adoption of this technology are not likely to be an automatic process.For example, in the case of South Korea the government has played a key role in a number of crucial areas including trade policy, technology policy and the role of foreign direct investment, thus enabling rapid technological improvement in the economy.

Following the UN Center on Transnational Corporations (CTC) 1987, the process of acquiring technological capacity abroad can be construed to consist of three stages :

- The transfer of existing technologies to produce specific goods and services;
- The assimilation and diffusion of those technologies in the host economy; and
- The development of indigenous capacities for innovation.

However, as much of what is currently regarded as technology transfer transaction is found lacking particularly in some of the characteristics associated with the last two stages, there has developed a heated international debate on the subject (UN,CTC, 1987).

Technological capability can perhaps be somewhat accurately described as the ability to internalise a basic core of functions which are needed to acquire, assimilate, use, adapt, change or create a technology (Lall, 1992). Dahlman, Ross-Larson and Westphal (1987), divide technological capability into three broad categories :

- Production capabilities, that is the capabilities needed to operate facilities;
- Investment capabilities, which are needed to establish and expand existing facilities; and
- Innovation capabilities, which are needed to create new technology or develop new products and services.

To this list, Lall (1992) adds *Linkage capabilities* which are defined as the skill enabling information, skill and technology to be received, at the firm-level, from outside agents including input suppliers and technology institutions, and to be transmitted to other firms, which will then permit the diffusion of this technology throughout the economy, thereby providing the potential for the expansion of the industrial base.

.Technological capability is clearly more than just the know- how necessary to operate equipment and produce output. There have, of course, been instances in the process of technology transfer through foreign direct investment for instance, where the host country has received little more than the ability to apply a given foreign production technique in an unadapted form, often inappropriate to local conditions and factor endowments. Such instances cannot be deemed to be beneficial to host economies and illustrate the need for the development of technological capability.

Lall (1987) provides a fuller breakdown of the composition of technological capability, the development of which would lead to more appropriate and beneficial investment being undertaken. At an initial level, it implies a certain capability and competence in making pre-investment choice. This involves a thorough search for available technologies including an appropriate package, equipment, and technique of production (based on its appropriateness to factor endowments and other local conditions).

A certain capability should also exist at the project execution stage, including capabilities in basic engineering, equipment specification, mechanical construction and workforce training. Since foreign technologies must usually be adopted to suit local conditions, the failure to develop adequate capability at this stage may lead to increased cost as the transfer or may be called on to undertake this adaptive work with substantial charges (Lall notes the estimate made by Teece (1976) that in such cases, more than 50 percent of the total cost of the project may arise from the cost of the technology transfer itself).

Basic capability must also exist in plant operation including normal day-to-day running and capability to adapt and improve the technology within the original design parameters, including introducing alterations to the raw material mix, product mix and other measures to increase efficiency and reduce cost.

Higher levels of technological capability include the ability to improve upon the technology itself by introducing a new product or process (Dahlman, Ross-Larson and Westphal name it *innovation capability*), and the technology transfer or linkage capability, where the firm or country has absorbed the technology well enough to pass this on to other firms or countries.

The benefits of developing indigenous technological capability at the firm and national levels extend to more than the prevention of the transfer of inappropriate technology. More positively, technological progress is one of the prime movers of the economy. The World Bank concurs with this and suggest that productivity growth, which they take as a proxy for technological change, has accounted for up to 30 percent of GDP growth in East Asian countries (World Bank, 1991). At the national level, technological growth will determine industrial and export growth and diversification, while at firm level it will reduce the cost of acquiring technology as well as reducing overall costs and providing new products, thereby increasing the firm's competitiveness. Without developing a certain level of technological capability, infant industries will never mature and the economy, as a whole, will be left with a far more shallow, uncompetitive industrial base.

Having established that the development of technological capability is desirable, it must be stressed that there are costs involved in this process. The cost of investing in the human capital necessary in the process can be substantial and tends to rise as firms undertake more complex tasks. After the basic core of *know-how* technology has been internalised, it is not always necessary to invest further in *in-house* technological development and the choice must be faced as to whether to buy or develop new technologies.

Dahlman (1987) suggests that only the capabilities or technologies which can be used cost-effectively all or most of the time should be developed in-house (or domestically). The other capabilities may be obtained from external sources.

ACQUIRING TECHNOLOGICAL CAPABILITY

Turning now to mine how the process of technology transfer can be used to acquire technological capability, Dahlman (1987) suggest that the potential acquisition of this capability should form the basis for the choice of technology should not rest on static cost and benefit criteria but on dynamic gain.

In assessing technologies to be transferred it is therefore advisable to examine local conditions and needs, with a view to how the chosen technology can be adapted to fit these. The field of technological choice should then be broadened as far as possible before each is evaluated on its present production merits and on its dynamic potential for modification and improvement. It is not necessary, nor may it be advisable to choose the latest technology. If this is choosen without a full understanding of how and why it works, it will be impossible to develop and improve on this technology later, leading to continued reliance on foreign assistance as the technology frontier shifts out further.

Developing countries typically develop technological capability through a sequence of production, investment and innovation; a reversal of the typical developed country sequence. Technological capability therefore, emerges at the production stage of the transfer process where much of the learning takes place. This stage of learning can take several years and often may be undertaken while foreign personnel provide various on-site services. Local participation in the design and construction of the plant itself prior to production is a useful means of developing investment capability.

Dahlman (1987) goes on to outline specific method available for transferring technology. Direct foreign investment, he suggests, either in the form of a joint venture or a wholly owned subsidiary, is the only way to acquire the latest technology from abroad. However, with a lack of local control over design and operation, there is limited potential for assimilation and absorption of the technology employed.

Licensing agreements also ensure rapid acquisition of product or process know-how, but potential adaptation and absorption of technology are again limited. With turnkey project potential for absorption is even more limited where foreign personnel are responsible for all aspects of construction and set up.

Purchasing foreign capital goods provides more potential for the diffusion of technology and can act as a model for local machinery manufacturing. Fransman (1986) notes the advantages of importing foreign capital goods as being less costly than local designs with less uncertainty regarding production and marketing. He notes also, however, that the country importing such capital goods may often be at a distinct disadvantage in terms of international competitiveness, particularly when goods have a shorter life cycle due to rapid innovation, e.g. computer-numerically have controlled machine tools.

Finally technology may be acquired through purchasing technical assistance from abroad, which may be easier, quicker and cheaper than spending the time and effort necessary to build up local provision of technology. However, the danger to be avoided with this strategy is an over-reliance on foreigners.

There are no rigid divisions between what type of assistance is and is not available. Different packages from different suppliers may be offered including training and experience in design, construction and operation of plant and equipment, assistance with adaptation and modifications of the technology and access to future improvements in the technology. For this reason, the purchasers of the technology should be aware of the options available and should negotiate a package which will provide as much information and understanding during the transfer as is needed, which is substantiated by Dahlman's saying: "The critical thing is to know what is needed and to seek it at the most reasonable price under terms that do most for the acquisition of technological capability." (Dahlman et al, 1987).

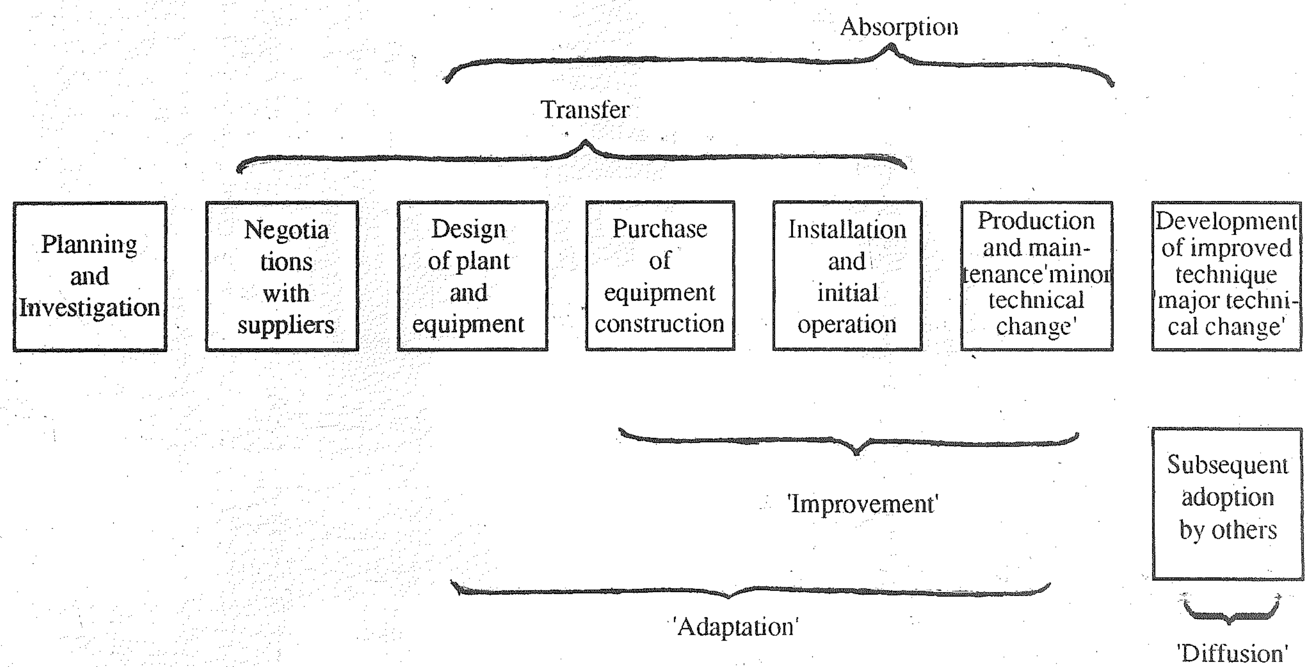
No adequate theory has yet been formalised to describe the process of technological development, Figure1, however, is helpful in illustrating the process of incorporating foreign technology.

INDUSTRY STUDIES : EVIDENCE FROM BANGLADESH

Industry studies conducted in Bangladesh by Huq and Islam (Huq and Islam, 1992) provide some revealing information, firstly, on the positive side, about the role of science in technological progress, e.g. in the case of fertilizer manufacturing from natural gas and secondly, on the negative side, about the poor state of technology transfer. The production of fertilizer has attracted tremendous interest in research and development from the major technology suppliers in the world, thanks to the subject being a part of basic research in chemical science and also to the prospect of large benefits that follow from the sale of plant design and production processes to potential customers (Huq and Islam, 1992). Saving in the use of feedstocks (e.g. coal, naphtha and natural gas) has remained an important area of interest in such research. By economising on the use of feedstocks and catalysts it is possible to reduce the unit cost of production. The production process also demands extensive use of energy, and any possibility of economising on the use of energy, other things being the same will obviously help in reducing the unit cost of production. As the feedstocks used also form sources of energy, energy saving has remained the main objective of various research and development efforts in this particular technology.

Figure 1

Flow Diagram Illustrating Activities in Process of Incorporating Foreign Technology



Source: S.L. Enos and W.H. Paru (1988).

An important outcome of the R & D efforts in the fertilizer production process is the use of steam driven centrifugal compressors, as against the conventional reciprocating ones driven by electricity. The reciprocating compressors are highly demanding in terms of energy, while the centrifugal compressors are driven with steam generated within the plant, thus enabling significant savings in energy. There have also been other improvements, e.g. in the use of catalysts, but the saving of energy in the running of compressors has remained a fundamental one.

The resultant technical progress has produced a new technology which has enabled improvement on various aspects (Table 1). In the absence of better terminologies the old technology is referred to as the conventional technology variant (which is a relatively small scale one in the context of the fertilizer industry) producing approximately 60,000 tonnes of ammonia and 100,000 tonnes of urea per year, and the new one as the improved technology variant, (which is a large scale plant) producing approximately 330,000 tonnes of ammonia and 560,000 tonnes of urea per year.

Table 1
Cost Advantages of Improved Technology Over the Conventional Technology in Fertilizer Manufacturing

(PVC in Taka per tonne : 1988-89 prices)*

	Fixed Capital	Working Capital	Natural Gas	Chemical	Energy and Fuel	Packing	Spare Parts and Maintenance	Wages and Salaries	Overheads	Total
Conventional Technology Variant (CTV)	3548	108	489	95	122	98	93	353	284	5190
Improved Technology Variant (ITV)	1491	54	410	48	79	206	47	69	233	2637
Ratio of Improvement of ITV over CTV	2.4	2.0	1.2	2.0	1.5	0.5	2.0	5.1	1.2	2.0

* Present value of costs at 10 percent discount rate.
Source : M. M. Huq and K. M. N. Islam, *Fertilizer Manufacture in Bangladesh*, University Press Ltd., Dhaka, 1992, p. 67.

The fertilizer industry in Bangladesh has been extensively built up over the last three decades and both the above technologies, received entirely through foreign aid, are found operating in Bangladesh. The heavy dependence on aid has not, however, helped Bangladesh to absorb the technology. The recipient, i.e., Bangladesh has only achieved production capability and some form of maintenance capability. In other areas, e.g., in the manufacture of machinery and equipment, use of local engineers in plant design and supervision of construction, the achievement in terms of technological capability is nil or negligible. Surprisingly, Bangladesh has got a big capital goods sector and, with proper commitment from the government, it would have been possible to make extensive use of the domestic facilities available. Indeed, according to a study by the Bangladesh Steel and Engineering Corporation (BSEC), as much as 37 percent of the total project work - in the form of structural steel works, storage tanks and pressure vessels, including piping of a large scale fertilizer plant-can be completed locally. (BSEC, 1988). Unfortunately, none of the fertilizer plants of Bangladesh, even the latest one at Chittagong (which came into production in 1987) and the recent one at Jamalpur (1991), makes any extensive use of the domestic facilities. Consequently, Bangladesh has largely failed in acquiring technological capability in the manufacture of fertilizer in spite of its heavy involvement in the industry over the last thirty years.

TECHNOLOGICAL CAPABILITY : EXPLANATORY VARIABLES

Most studies published on technological change in the Third World have until now been carried out by detailed case studies of industries in developing countries, including the collections of descriptive material and data as basis for drawing conclusions. With respect to the development of technology, there seems to be a growing agreement between researchers and to the factors involved in the process. However, this approach is limited because it is not capable to determine the relative importance of each of the factors identified, and it leaves open to question the true pattern of causation.

A more scientific approach to the analysis of Third World science and technology indicators is that of multiple regression analysis. An example of this can be found in Huq (forthcoming), where the following regression model is used to determine the explanatory factors of variations in technology absorption, across individual machinery manufacturing firms, in Bangladesh.

$$\text{Tabs} = f(\text{AGE}, \text{GCM}, \text{SK}, \text{FI}, \text{ICR}, \text{WC}, \text{MNT})$$

where,

Tabs	=	Technology absorption achieved by an individual firm, measured in percentage;
AGE	=	Age of the firm since establishment (in years) ;
GCM	=	Level of government commitment measured in scale towards production of the individual firms reflected in import, local purchase, tariff, credit and other policies;
SK	=	Share of skilled workers to total labour force ;
FI	=	Fixed investment of individual firms, measured as an index;
ICR	=	Share of institutional credit to total investment;

WC = Dummy variable for working capital, with value 1 for firms reporting existence of WC constraint, 0 for no such constraints;

MNT = Dummy variable for management constraint, with value 1 for firms reporting existence of MNT constraint, and 0 for no such constraint.

Table 2

Determinants of Technology Absorption in the Bangladesh Machinery Manufacturing Sector From Regression Results

	Equation 1	Equation 2
Intercept	33.28*** (2.74)	28.03*** (2.04)
AGE	0.2347* (1.93)	0.2356* (1.85)
GCM	5.11*** (2.84)	4.01** (2.01)
SK	0.0337 (0.16)	0.2962 (1.55)
FI	-2.06E-05 (-1.23)	3.04E-04 (0.77)
ICR	0.0590 (1.42)	0.0427 (1.10)
WC	0.8401 (0.2510)	2.30 (0.80)
MNT	-2.91 (-0.88)	-3.46 (-1.09)
R^2	0.5922	0.4871
R^2	0.4864	0.2917
F	5.60 ***	2.49 **
N	35	30

*** Significant at 1 percent level.
** Significant at 5 percent level.
* Significant at 10 percent level.

Note :
Equation 1 uses observation based on 30 private and 5 public sector enterprises.
Equation 2 uses observation based on 30 private sector enterprises only.
Figures in brackets show estimates of t-value.
Source : Huq et al. (forthcoming)

It is apparent that in both equation 1 and 2 the coefficient of government commitment (GCM) emerges as the significant explanatory variable. Indeed, as found by Huq, (forthcoming) the absence of systematic government policy to exploit the potential of the machinery manufacturing sector has not helped the promotion of technological capability in Bangladesh. Government involvement is reflected in various ways : tariff policy, technology transfer negotiations, aid negotiations, management of public sector projects, credit policy towards private sector, export policy, and R & D support, but in many of these areas government commitment is lacking. The failure of the government to demonstrate its commitment to public sector engineering plants is apparent from the continued import of machinery and equipment which can be locally produced, using the huge installed capacity existing in the country. Intentionally or unintentionally the government has failed to negotiate aid contracts properly. The *self reliance* objective, repeatedly put forward in the various plans and other policy documents appears hollow as the local capability has been ignored and the local demand for the various engineering products is being satisfied through import, inspite of the fact that government policy heavily aims at utilising domestic capability. In the Fourth Five Year Plan of Bangladesh (1990-95) there is a categorical statement for utilising the machinery manufacturing sector : "...efforts will be made to manufacture as much capital goods within the country as possible. Imports of capital goods will be limited to specific items for which domestic capacity does not exist." In the face of such statements one wonders whether the government is aware of the extensive installed capacity that exists in Bangladesh.

CONCLUSION

The above finding by Huq et al is in line with the suggestion, strongly advocated by Enos and Park, Lall, and many others that government must play an active interventionist role in developing technological capability. This ranges from investing in human capital through training and education, and provision of incentives through subsidised credit at favorable interest rates as well as selective (but not excessive) protection of industries, or the encouragement of domestic and international competition as an inducement for firms to increase product quality and/or lower cost.

It is stressed that the government plays a critical part in ensuring the successful absorption of technology throughout the transfer process. A key role is that of negotiating terms for the transfer and ensuring that the suppliers of the technology do not abuse their monopoly power. For example, the government may intervene to impose limit on royalty payment to the supplier or may prohibit the terms which restrict production for export. In order to foster the development of local capability, requirement may be placed on technology importer to document that the desired technology is not locally available.

SELECTED REFERENCES

Bangladesh Planning Commission, (1990), *The Fourth Five Year Plan, 1990-95,* Bangladesh, Dhaka.

Bangladesh Steel and Engineering Corporation. (1988), *Proposal For Local Participation in the Construction of Jamuna Fertilizer Project and Karnaphuly Fertilizer Project* . BSEC, Dhaka.

Cooper C. and Kaplinsky, R.(1989), *Technology and Development in the Third Industrial Revolution,* Frank Cass P. 2.

Dahlman, C.J.B.,Ross-Larson and L.E. Westphal (1987), "Managing Technological Development : Lessons from the Newly Industrialising Countries", *World Development,* Vol. 15, No. 6.

Enos J.L. & W.H. Park (1988), *The Adoption and Diffusion of Imported Technology : The Case of Korea,* Croom Helm, London.

Fransman M. (ed 1988),*Machinery and Economic Development,* MacMillan, London.

Huq, M.M., K.M.N. Islam and N. Islam (forthcoming), *Machinery Manufacturing in Bangladesh : An Industry Study with Particular Reference to Technological Capability,* University Press Limited, Dhaka.

Huq, M.M. and K.M.N. Islam (1990), *Leather Manufacturing in Bangladesh,* The University Press Ltd. , Dhaka.

------------ (1992), *Fertilizer Manufacturing in Bangladesh,* The University Press Ltd., Dhaka.

Lall, S. (1987), *Learning to Industrialise : The Acquisition of Technological Capability in India,* MacMillan, New Delhi.

Lall, S. (1992), "Technological Capabilities and Industralisation", *World Development, Vol. 20, No.2* .

Metcalfe, S. (1987), "Technical Changes," in Eatwell et al *The New palgrave : A Dictionary of Economics Vol. 14,* The MacMillan Press, p. 671.

Smith, A. (1982 first published 1776), *The Wealth of Nation Book I,* Penguin Books.

Schumpeter, J.A. (1943), *Capitalism Socialism and Democracy,* Allen and UnWin, London, pp. 31-32.

United Nations (1987), *Transnational Corporations and Technology Transfer : Effects and Policy Issues,* Center on Transnational Corporations, New York.

World Bank (1991), *World Development Report* 1991, World Bank, Washington, D.C.