TECHNICAL AND MANAGERIAL ISSUES IN TECHNOLOGY ADOPTION FOR LARGE SCALE FARMING - EXPERIENCE OF CARONI (1975) LIMITED

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Few would argue with the proposition that technological innovation lies at the heart of successful agricultural development. Yet the transformation of traditional agriculture remains largely incomplete as more than half of the world's agricultural producers operate under technological constraints that have changed during the twentieth century. This situation is not a consequence of lack of effort to find new technology - almost all the less developed countries have attempted to introduce new intermediate inputs (seeds and fertilizers) or new capital inputs (animal or mechanical devices). Government policies related to land improvement, investment, credit availability and controls over importation of inputs such as fertilizer are partly to blame for the slow rate of generation and diffusion of new technology. But more important market and subsistence oriented farmers alike have shunned new technologies because they offer lower profits or productivity than the traditional technology. Thus, the problem of technological change lies primarily with the appropriateness of the new technology for the biological and economic environments of the technology seeking country.

ROLE OF TECHNOLOGY

Almost every question in economic development leads to technology. H.J. Brunton compiled empirical evidence from numerous studies on technology and concluded that an increased quantity of physical inputs (capital and some quality labour) rarely accounts for more than half the increase in gross domestic product. The remainder of the increase must be assigned to productivity in increases which take the form of better management capabilities or new techniques of production. We think of technology in two senses, embodied and disembodied. Embodied technical change occurs when new machines and processes combining with other factors of production raise the productivity of those factors. Disembodied progress on the other hand refers to the unexplained increment. An entire set of potential forces and new processes promote greater efficiency in the use of resources such as more highly skilled labour, re-organisation of plant layout, improved accounting for inventories and cash receipts, firmer labour discipline, etc. The technology is disembodied in that one cannot point to a new machine or other visible input that causes the increased ouptut. Disembodied technical progress is generally measured with some standard production function. The production function measures the output increments due to increased inputs/outputs in excess of this is due to disembodied change.

THE "VIRTUOUS CIRCLE"

Technical change becomes so intermixed with fundamental forces of change that it is impossible to extricate it from the process of development itself.

These fundamental forces include increased income (and thus greater demand for agricultural and industrial products), new investment, deployed differently from before, urbanization, shifts in political power from a land based aristocracy to an urban manufacturing elite, a changing role of international trade and more. Historical evidence sheds light on the functioning of the "virtuous circle" of technical change which leads via increased demand to further improvements in technology, changing consumer demand and malleable public tastes assisted the Anglo-American transition from handicraft to highly specialized machines. The exceptional productivity growth in the Republic of Korea and Taiwan during the second period demonstrates how developing economies can benefit from technological change.

DEFINITION OF TECHNOLOGY

A technique is a way of doing something such as producing a good or service. It has many dimensions both physical (engineering or architectural) and economic. The former are spelled out in precise designs. The latter derived from the former with the application of prices can be described as the amounts and values of productive inputs. As generally used in economic literature, technology is the entire set of techniques that are or may be used for a given output. World technology or the technology shelf consists of all the technologies that have existed. Some have become obsolete for engineering reasons such as when new technology requires less of all inputs. Others are no longer used for economic reasons which may occur, for example, if the cost of labour increases relative to the cost of capital. The former group are not optimal anywhere in the world, but the latter now obsolete in MDC's might be optimal in LDC's where labour remains abundant and capital scarce. Appropriate technology is defined by William Lochr and John Powelton in their article on the Role of Technology as efficient technology is the set of techniques that minimises the social cost of pursuing socially approved objectives.

THE CHOICE OF TECHNOLOGY

Many technologies in the less developed countries have not been appropriate. In principle, one expects low wages, capital poor countries to produce with more labour intensive techniques, rather than with capital intensive techniques found in high wage capital rich countries. However, in the real world if only one technology is known, there would be no choice of technology and the relative factor prices would become irrelevant.

Another reason why productive techniques in Third World countries tend to be more capital intensive than is expected is that prices are distorted. Overvalued exchange rates, artificially high wages, restrictive hiring regulations, interest subsidies, etc., all tend to lower the price of capital and raise the price of labour such that more capital intensive techniques become more profitable.

In the early post-war years, capital and labour were considered not to be substitutable for each other in a large number of operations. It was thought that for most cases there was one modern production function i.e. a given amount of capital would require so much labour and no more and vice-versa for a given amount of labour.

Prices are distorted by government either for political reasons or through ignorance thereby resulting in the use of capital intensive techniques. Centralized planning common to many of the Third World countries may be biased in favour of capital intensive methods. There is a general tendency to overestimate capital availabilities and when this is realized, it is too late to change. The working of the bureaucracy might prevent the revision of earlier decisions. Capital intensive methods may be less risky than labour intensive ones. Engineering criteria may dominate economic criteria. Decision-makers might seek the technology producing the best product though the increment of superiority may not justify it.

AREA NEUTRAL TECHNOLOGY

A considerable part of modern technology is either area neutral or can be made area neutral with certain adaptations although some of it may originally have evolved in the context of relatively big farms. Some examples are genetic modification of plant materials, biological nitrogen fixation, fertiliser utilization and nutrient absorption, chemical growth regulators, pest control, improved water use and irrigation, multiple and inter cropping, land improvement, no tillage cultivation, controlled environment agriculture, nutrient film technology, by-product utilization, etc. Some of these techniques can be applied to small farms to a much greater extent than they are today. Prima facie biological and chemical technologies appear to be more applicable to small farms than are mechanical technologies. However, many of the mechanical technologies can now be adopted to the needs of small farms through the efforts of modern research.

CUSTOM WORK OR EQUIPMENT RENTAL

Some technology that is not area neutral itself may be made available through operational arrangements such as custom work or rental or hire purchase. In fact, renting a relatively large piece of equipment for limited periods may sometimes by significantly more efficient and economical. Schemes for promoting the use of custom work and rental or hire purchase of costly equipment have not yet been given the attention that they deserve in Third World countries. The availability of timely and adequate credit combined with insurance especially for hire purchase is indeed a key to the development of farms, large and small, especially the small ones. Along with rental or hire purchase of equipment, it is important that adequate servicing, spare parts supply and repair facilities must be provided, preferably by the same agency. If some of the large scale agricultural machinery manufacturers had taken the same care, to study local needs and provide the supportive services in rural areas of developing countries, that some automobile and petro-chemical manufacturers have used in the urban areas of developing countries, modernization of farms might have occurred much faster.

LABOUR AND CAPITAL INTENSIVE TECHNOLOGY

Nowadays it is common to contrast labour intensive and capital intensive methods especially when one considers small farms. In fact, there needs to be no contradiction between these two methods.

In actual fact, labour and capital may play a very useful and complementary role in overcoming the basic scarcity of the third factor, namely land. Intensive labour application on a scarce land unit undoubtedly helps to increase its yield. But it does not by itself improve the productivity or wage of labour; this can occur only when intensive use of capital accompanies intensive use of labour in such a way that yields per unit of both land and labour increases so that every measure in food production is accompanied by an increase in per capita income of the worker.

In some countries, it was felt that the small size of the farm was an inhibiting factor in itself. An attempt was, therefore, made either to collectivise these farms or replace them by large scale capitalistic farms or plantations. In a number of cases this, no doubt, increased the marketable surplus, but in most cases it did not improve the yeild per acre.

In some cases it created a problem of surplus labour which could not be quickly absorbed in other sectors of the economy and this had its social costs.

In certain other countries it was felt that increased yield per acre of small farms was possible by intensive use of labour alone so that whatever capital was available could be conveniently diverted to industrial and other non-agricultural uses. The result was usually a short spurt in agricultural output but not a sustained process of agricultural development.

It is important that the error of both these approaches is recognized. Agriculture, no less than industry, needs progressively intensive use of capital. Intensive use of man power can certainly help but it cannot substitute for capital except for a short period.

Intensive use of labour will be helpful for the adoption of the many biological and chemical innovations which modern science has made or is about to make available, but intensive use of capital will be needed to get the best results.

This will include the provision of the degree of mechanization that is required for optimum efficiency of available labour and for progressive improvement in its remuneration. The bulk of the capital may be used in the form of improved seeds, better and larger applications of plant food, water and pesticides, items of small equipment, but part may also be used for providing the service of heavy equipment on a cooperative or custom basis.

The size of a farm need no longer be the inhibiting factor that it was in the past. In fact, a half hectare farm using what is called "nutrient film technology" can produce per annum as much as a 4 to 7 hectare farm using conventional technology.

TECHNOLOGY - PROBLEMS IN PRODUCING ONE'S OWN OR ADAPTING ONE

The introduction of a new technology by local innovation or transfer from outside requires advances in knowledge and changed availability of inputs. Increased agricultural productivity results from sequential advances in knowledge, changes in the supply of new material inputs and advances in producers' know-how. Advances in

knowledge are differentiated into two categories: one set consists of material things which have come from basic discoveries in the sciences and engineering. The advance in knowledge in this case becomes inextricably associated with the material substance, e.g., knowledge with respect to genetic engineering becomes part of the genes. The other set consists of changes in farm practice.

Production functions can be modified without introducing new material inputs, e.g., changes in rotation, tillage, cultivation practices, seeding rates, irrigation techniques, etc. In all cases total resource availabilities are unvaried nor are scale economies involved. Skills become perfected. The key point is that the change in farm management practices involve improvements in the use of modern technologies.

The theory of induced innovation introduced by Hayami and Butan (1971) focuses on those cases where technologies are produced and diffused indigenously. Factor scarcities or factor prices influence the direction of technical change for the production of a particular commodity. Technical change is directed toward saving the scarce or more expensive factors, that is saving proportionately more of the scarce factor than of the abundant factor per unit of output measured at constant prices.

The theory of induced innovation suggests with some qualifications that technical change can be treated as indigenous to the development process. The key element of the induced innovation process is the presence of a response by researchers to local resource scarcity and an information dissemination network. Research scientists are aware of the resource constraints and are responsive to these constraints when their salary and job security are somehow dependent on their contributions to the development of new technologies. An extension service or news information service provides an avenue whereby the needs of the producer can be transmitted to the scientist. This network is lacking in most of the less developed countries. The less developed countries account for only 4 per cent of world agricultural research and development expenditure and only 1 per cent of global research and development expenditures in health, agriculture, housing and industrial technology (Paarl berg, 1982). As a result, less developed countries lack national agricultural research comparable to those which exist in any of the major advanced agricultural countries. Even in the moddle income countries which have some long established research institutes there are inadequate means to keep abreast of advances in the biological sciences, laboratory and field methods and equipment.

It is difficult to explain why developing countries have not spent more money on research and development in order to derive the maximum benefits from such investment.

Many developing countries have introduced technology for large scale farming from the developed countries with little success. The reason for the lack of success lies mainly in the fact that the conditions necessary for the successful adaptation of the technology have not been developed. The technical knowledge required from the persons who have to use the knowledge is usually lacking. The standard of education of the workers, the skills possessed, and the services, e.g., repairs, spare parts, etc. are lacking. Before a new technology can be adapted to meet local conditions, the necessary research and development studies must be undertaken. The question often arises who

must bear the cost. Will the private sector bear this cost? Very often the private sector is not willing for several reasons. It may not be profitable in the short run. Large scale mechanized farming may be in conflict with the government policy. The introduction or modification of the technology might result in increasing unemployment in the short run. This may not be acceptable to the government. The demand for the adapted technology might not be sufficient to warrant the expenditure. The facilities, e.g. workshop expertise, etc. necessary may not be available and government policy might prevent the importation from abroad. Work permits may not be readily available.

The educational system in the country may be producing graduates who are unable to man the technology or to affect the adaptation.

Research laboratories, experiment stations and extension organizations themselves are no guarantee of generating and diffusing appropriate technologies but they are critically important in linking scientists and institutions to agricultural producers and farming communities. Failure to develop these linkages via changes in national investment policies can only help perpetuate the dominance of traditional technology in agricultural production.

CARONI (1975) LIMITED EXPERIENCE

Caroni (1975) Limited is a limited liability company which was incorporated in Trinidad and Tobago on March 26, 1976 under the provision of the Companies Ordinance. The Company is wholly owned by the Government of Trinidad and Tobago. The Company has under its control 71,000 acres of land, 4 sugar factories, 1 sugar refinery and 1 rum distillery with the necessary infrastructure to produce sugar, rum, meat, milk, beef and food crops.

The Company has been making losses for the last ten years in its sugar operations and has decided to diversify its operations in order to become viable.

In 1982 Caroni developed a plan to diversify its operations along the following lines:

(i) to marginally reduce the acreage under sugarcane to 14,974 ha. by 1987;

(ii) utilize former sugarcane lands to:
  (a) grow 812 ha of irrigated paddy;
  (b) produce 1,000,000 litres of fresh milk annually by expanding its dairy herd from 100 to 200 milk cows and followers;
  (c) expand its beef production from the water buffalo by increasing its herd of "Buffalypso" cattle from 500 to 1,000 animals;
  (d) produce pedigree stock of Buffalypso cattle for local farmers and export, by expanding its breeding unit;
  (e) establish 405 ha of Robusta coffee;
  (f) establish 202 ha of citrus mainly oranges for Trinidad's juice industry; and
  (g) cultivate annually 240ha of high-yielding cultivates of cassava to produce fresh and frozen tubers, and utilize the surpluses in the domestic animal feed industry.

(iii) modernize the Company's run distillery operations;

(iv) produce yeast; and

(v) resuscitate Trinidad's bagasse-board production, by making operational its bagasse-board plant recently "moth-balled"

by Caroni.

The rest of the paper will attempt to highlight the experiences of the Company in one of the projects, e.g. paddy production. The paddy production project has been very successful so far while in the case of the cassava project the project is a complete failure to date.

PADDY PROJECT

The Company decided that since it had no experience with the production of paddy, that it would plan the project in detail and then execute the plan in stages.

The project was divided into the following phases:-

(a) feasibility study
(b) identification of project area
(c) pilot project
(d) design of entire project
(e) financing
(f) evaluation of progress
(g) implementation in phases.

FEASIBILITY STUDIES

The Corporate Planning Department conducted feasibility studies which showed that the project on completion could produce rice at prices that would be competitive with the price that the government was paying for the imported product from its Caricom partners. The Company decided that it would embark on commercial paddy production.

PROJECT AREA

The project area was identified after considering the soil and other characteristics and the availability of water for irrigation. Two thousand acres which were under sugar cultivation were earmarked.

PILOT PROJECT

An area of 150 acres was earmarked for the pilot project and the Research Department was asked to conduct the pilot project commenced in 1982.

The pilot project enables the Company to determine:-

(i) the type of machinery for the large-scale cultivation of swamp paddy;
(ii) the cultural requirements of swamp paddy under Trinidad conditions;
(iii) the water control requirements;
(iv) the feasibility of aerial application of pre-germinated seed, fertilizers and pesticides; and
(v) the indicator of yields.

After a number of implementation delays associated with the development of the infrastructure, three crops of paddy were grown under upland conditions. Subsequently a crop of swamp paddy was planted in June 1984 and harvested in October 1984. The average yield obtained was in the order of 3.8 tonnes/ha. These yields were considered satisfactory against a long established industry average for Guyana of 4.75 tonnes/ha. The pilot project has continued as a

seed farm.

THE PROJECT RATIONALE

The Company decided to enter into large scale production of paddy using modern techniques for the following reasons:-

(i) the Company has large tracts of suitable idle lands which can be converted to this enterprise;
(ii) the technology for large-scale mechanised paddy production is available and substantial technological modifications and transfer have evolved out of the results of its rice pilot project;
(iii) some "in-house" expertise in paddy production is available to the Company;
(iv) GOTT's Rice Mill Complex at Carlsen Field which is largely underutilised due to a shortage of throughput, is in proximity to the proposed project site, approximately five miles;
(v) this crop can be grown and harvested with large inputs of mechanisation thus reducing the use of expensive labour; and
(vi) the use of irrigation by the Company will enable it to grow two crops of paddy per year.

PROJECT DESCRIPTION

The project consists of the phased development of an 812 ha rice farm on former sugarcane lands. It will include the construction of physical infrastructure and the procurement of agricultural equipment for the irrigated production, transportation and storage of paddy for milling into rice. The project will be developed in five phases comprising 12, 130, 300, 270 and 100 ha respectively. A description of the major components is as follows:-

Infrastructure Works

(i) the removal of existing vegetation from the project area;
(ii) construction of a water conveyance system consisting of a network of main canals, lateral canals and canal structures to supply and distribute water to the paddy fields;
(iii) development of 157 basins ranging in size from 0.5 to 10.4 ha. This will involve land levelling to produce the required grades, the construction of levees to farm the basins and the construction of inlet and outlet controls;
(iv) rehabilitation of the existing drainage system in the project area; and
(v) procurement of mobile pumps for raising the water from both the Guaymare and Caroni rivers into the irrigation canals.

Agricultural Equipment and Machinery

Procurement of:

(i) land preparation, crop maintenance, harvesting and transport equipment; and
(ii) paddy storage silos.

Engineering Services and Management

(i) engineering services for the preparation of land surveys,

designs and contract documents and the technical inspection and certification of construction; and

(ii) project management.

DESIGN OF THE PROJECT

The Company employed the Israeli firm of Tahal Consultants Limited to design the entire project. The firm was asked to design in detail the infrastructure works required, cost same, and include the cost of supervision of the implementation as well.

The firm completed the design and provided the cost estimates in six months time. The Company examined the design and accepted the same but did not accept the cost estimates. The cost of supervision was considered too costly.

FINANCING OF THE PROJECT

The Company encountered difficulty in funding the project. As a result, the Company approached the Caribbean Development Bank (CDB) for a loan to finance the entire project. The CDB took two and a half years to approve the loan. However, the Bank indicated at the outset that the project appeared viable and indicated that funds would be provided on condition that the Bank's conditions were met. The Company, having been assured that the funds which it invested before would be credited as part of its contribution, proceeded with the first phase of the commercial production. The project is estimated to cost US$6.6m. The Bank would finance US$4.3m and the Company $2.3m. Phase 1 of the commercial production was completed and the tender for Phase II awarded before the loan was approved.

The financial analysis showed that the project would yield a financial rate of return of 31 per cent to all resources and a 59 per cent to equity.

IMPLEMENTATION OF THE PROJECT

The infrastructure work is being undertaken by contractors. The supervision is done in-house by experienced persons who have been recruited on contract for the project. By this method the cost of implementing the project has been reduced considerably.

The cultivation of the paddy is being undertaken by Caroni's staff. The project is being mechanised as fully as possible.

The first crop in Phase I has been successful and the target yield of 2,500 lbs. surpassed. The project is being monitored by a multi-disciplinary team which report to the General Manager.

EVALUATION OF THE PROJECT

The project will be evaluated by the Corporate Planning Department from time to time.

GENERAL COMMENTS

This project has been successful for the following reasons:-

(a) the Company recognized from the outset that it did not possess the expertise to produce paddy on a large scale,

although it has extensive experience in the production of sugarcane on an extensive scale and that the experience could not be transferred without difficulty;

(b) the Company decided that it would plan the project in detail and take the necessary steps to introduce the known technology which was developed abroad, and then adapt it to the local conditions. This it did by the route of a pilot project. The difficulties encountered in the pilot project were overcome at minimum cost;

(c) the Company did not rely on its experience in cane cultivation for the large scale production of paddy. It recognized the need for trained and experienced personnel in paddy production and recruited a project manager, a hydraulic engineer and an agronomist, all of whom had extensive training and experience in the production of paddy in the region. These people were employed on the pilot project when the early difficulties were encountered;

(d) the Company did not design the project in phases. It designed the entire project which was done by a foreign firm;

(e) the Company did not employ the foreign firm which designed the project to supervise the implementation. The foreign firm did not have any experience in the region in large scale paddy production. The Company went via of trained and experienced personnel from the region. By this method the Company saved money and time and was able to adapt the technology to suit the local condition. Had the Company used the foreign firm, then the firm would have used the technology with which it was familiar;

(f) the Company has been able to adapt some of its equipment which it has in excess for its present and projected sugar operation to meet the needs of the rice production. Had the Company used the foreign firm, then the firm would have recommended equipment, etc. with which it was familiar;

(g) the project is being implemented in phases. As a result, the equipment and machinery needed for a phased execution is available. Had the project been implemented in one phase, then equipment and maybe contractors etc. would have had to be imported. This would have increased the cost and would have prevented any modification of the project or the technology;

(h) the detailed planning and phased implementation have prevented major bottlenecks in the project. The drying, milling, storage, transport, etc. facilities have all been carefully planned and steps taken to supply them as they are needed. The Company did not rely on its experience in sugar to execute the project. It devoted the time and energy in planning and executing the project and is prepared to adapt the technology and modify the plan as the need arises;

(i) the Company has been engaged in conducting research on varieties, etc. as well as in training the staff to meet the challenge of the project when it is completed;

(j) the training experience in large scale production of sugar, through extremely useful, is not sufficient to solve the technical and managerial problems of large scale production of paddy.