TECHNOLOGY CHOICE AND DEVELOPMENT

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INDEVELOPMENT

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1 DEFINITIONS

Technique and technology are both very complex and slippery terms. There are many different definitions, each with their own implicit meaning and consequently showing different conceptual approaches.

Technique; a definition

For the sake of simplicity we will provide a definition, which summarises most of the basic concepts in definitions, as presented in the various literatures.

Technique is the total of means and procedures, both immaterial and material for the sake of production and the marketing of existing goods and services, as well as the creation of new goods and services.

Technology

Technology may be defined as the application of the existing body of knowledge and skills to the production of goods and services. It can also be defined as the systematised, formalised, standardised, (generally) accepted and applied forms of techniques. Thus the concept of technology transcends the use of equipment, tools and encompasses the materials, procedures, processes, information and often the goods and services produced, and the way these are used.

Technology is normative

Technology does not create itself. Rather it is a direct outcome of choices and decisions of people, organisations, enterprises, communities, nations, etc. It therefore is not neutral rather normative.

ESCAP's view

ESCAP in "Framework for technology based development, 1989, Bangkok, distinguishes technology upon four characteristic features:

- *Technoware:* embodied in machinery, equipment and tools (but also buildings and infrastructure)
- *Humanware:* human abilities, embodied in persons skills and knowledge
- *Infoware:* documented facts, embodied in documents, like processes, procedures, specifications, observations, evaluations, blue prints, patents, etc
- *Orgaware:* organisational framework, embodied in institutions, management, organisation structures and logistics.

1.1 PRODUCT TECHNOLOGY

Product technology refers to the terms of reference of a product: the requirement the product has to fulfil. In practise, the specification or terms of reference for the product are generally a combination of requirements set by different interested parties: the end users, the designers, the engineers/consultants for particular aspects of the product and managers. The combination of requirements is usually laid down in documents as (standard) specifications and drawings of basic details of the product.

1.2 PRODUCTION TECHNOLOGY

The specification of the production process technology is partly determined by the terms of reference of the product. Still the specified product can be produced in a variety of ways. This means that in general it will be possible to identify a range of production process technologies that can be applied to

produce the required product. Each type of production process technology has its own mix of inputs.

2 TECHNOLOGY CHOICE

Cost-benefit analysis

If consumers want to buy (expensive) products, they compare the costs and its qualifications of that product with opportunities to use their resources for other products. Producers do more or less the exact same thing, while selecting their production technologies. They too apply cost-benefit analysis.

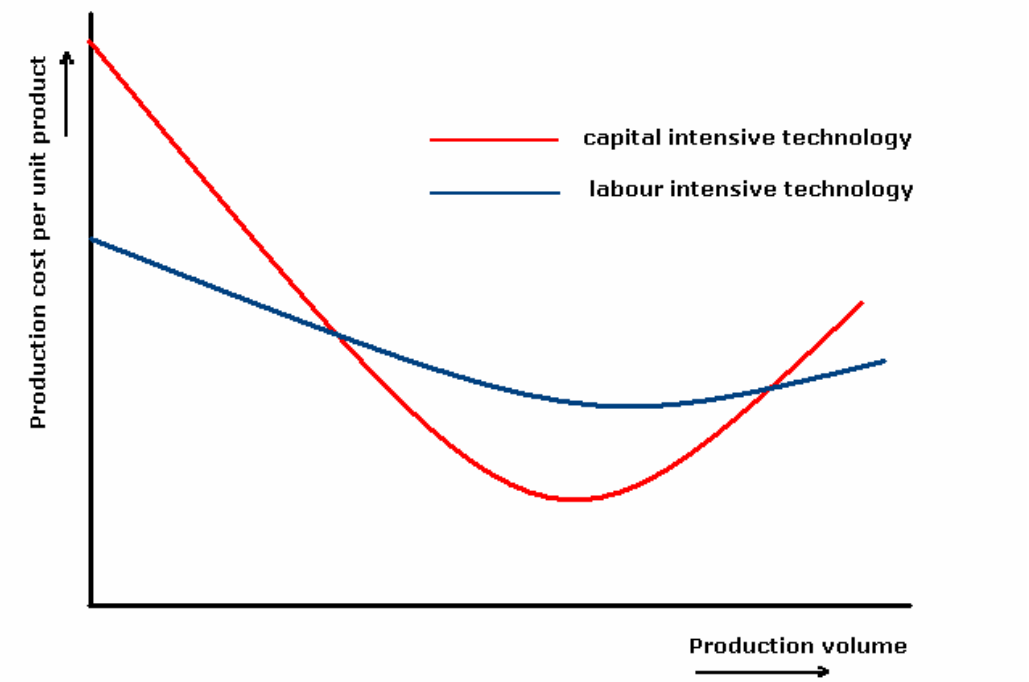
Schedule of requirements

The first step for selecting production technology is developing a schedule of requirements. This activity starts with a market analysis.
With regard to quality, so-called standard specifications of the product limit the freedom of technology choice. Even if there are no standard product specifications, the products should meet the quality requirements of its customers. A production process that produces inferior quality (in the eyes of the customers) will not generate any benefits.

Production costs

Producers aim at minimizing production costs. This is important in most industries, but certainly in the ones with heavy competition. Production technology choice influences production costs considerably. In particular when economics of scale apply. This means that the cost per product reduces with a growing production volume. In these industries the production capacity should be large enough to minimise production costs. However producers should be concerned if the market volume and their market share are large enough to make the best of the production capacity. Due to inefficiencies, an under-utilised equipment plant may result in higher production costs than a small and completely utilised production plant. Large companies producing various products may be able to use the same production technology and increase the utilisation degree of the technology. Clearly the multi-purpose specifications increase the need for a quick adaptable production technology.

The figure presented below, shows simplified unit cost curves of two theoretical technology options in relation to the production volume. The blue line describes a more labour-intensive production methodology and the red line a more capital-intensive production method. Because of the investments in technology, the company applying the capital intensive method incurs costs without production. Only when the production volume is larger than a certain point the higher productivity of the capital-intensive method will pay off. When the utilisation degree of the equipment is too high and preventive maintenance is postponed, the equipment will start to fail, adding more and unnecessary cost to the production.



Flexibility

Reduction of production cost is off course not a goal in itself. Companies aim at making profit on the long run. In industries where new product introductions and production technology developments are frequent, companies should select technologies that allow them to adapt production to changing product specifications. Companies operating in the more dynamic industries have to develop a strategy that allows them to modify, innovate and perhaps even invent improved production technologies.

Correcting volume

In certain industries, the product specifications may be quite static, i.e. construction, but the market volume may fluctuate considerably. In these industries, companies may benefit from production technologies which allow easy adaptation of production volumes in order to reduce production costs. As can seen from the graph above, the production costs of labour-intensive technologies react more to a reduction in production volume than capital-intensive technologies.

Expansion capacity

All companies think about expanding their market share and may consider expanding production at new locations. It is important for firms to think about these strategies prior purchasing production technology. There may be strings attached to the purchase of technology. Technology developments may not be allowed till the license expires or even worse the seller becomes the owner of innovations of the purchaser.

Adaptation

Production technologies may need adaptation. Most of production technologies are developed in the advanced economies. The operation environment in low and middle-income countries is differs considerably With these advance economies.

The plants in industrialised countries are considerably larger than would be required for the production for domestic market only. The plant may therefore have to be scaled down. This mainly affects parts of the plant that

easily can be separated and replaced by manual labour. The increasing labour-intensity may conflict with product norms that relate to fine tolerances, like the norms for interchangeable components.

The alternative "redesigning" to scale down the plant size is usually very expensive and it may be better to select another production technology.

Government regulations may require producers to use domestic suppliers of raw materials and components. The characteristics of these intermediate products affect both the production process and the final product.

It may also be necessary to adapt the product to specific demand characteristics and government regulations & standards for the domestic market.

In most situations the supplier of the production technology is in the best situation to adapt the technology to its new environment, because they usually have the capacity (technicians) and the technical understanding.

The producers themselves are more equipped to adapt products to the local market and government regulations.

2.1 TECHNOLOGY CHOICE CONSTRAINTS

Companies seldom have full freedom in their selection of production technology. Often governments set additional specifications or have particular considerations about the providers. The capacities to adopt and apply technologies are also limited, in particular so in low and middle-income countries.

Government regulations

Most governments limit the range of options with regard to purchases of production technologies. They have adopted laws about technologies because of its environmental or safety and health implications. In most countries it is forbidden to use environmental polluting products. Furthermore many countries have adopted standards with regard to quality aspects of the products. For example the commonly used British Standards specify the quality requirements of steel, concrete, timber or any other products. In addition many governments are imposing import restriction on equipment, manpower and spare parts.

Public services

Most production processes requires public service delivery like transport infrastructure, water and energy. Sub-standard public service delivery affects the production capacity, adds costs to production, but more importantly influences the schedule of requirements. Technologies are only useful when they remain in operation. Companies will not benefit from equipment that is sensitive to power cuts.

Information

Purchasers can only choose between alternatives when they are aware of their existence. Many companies in low and middle-income countries are not able to access information about technologies from abroad. Fortunately this situation is rapidly improving through the internet. Larger companies use international tender procedures to obtain information about technologies.

Technical capacity

Production requires engineers, managers, technicians and trained production workers. Innovation of technology also requires engineers and researchers. Companies may have to recruit and train staff in order to apply certain production processes. However there is only so much a company can do. Education systems in the end set limits to the flexibility of the work force to work with different technologies. Many low and middle-income countries lack mid-cadre technicians and managers.

Financial capacity

Financial limitations are often the most cited problem among small business owners. Banks seek guarantees that their loans will be repaid. Company and personal assets that can be used as collateral often set the upper limits for loans. These upper limits can be stretched if companies can submit copies of insurance companies that safeguard banks against bankruptcies, natural disasters and other problems.

3 PURCHASING TECHNOLOGY

Sources of technology

The majority of companies do not have the capacity to develop their own production technologies. They purchase them on the market. In an open economy, companies have the option to purchase from domestic and international sources. Production processes often involve various steps and thus various production technologies. It is therefore possible that companies obtain technologies from different sources and different parts of the world. As stated earlier, most technology is developed in advanced economies. In addition in many low and middle-income countries there is only a limited number of technology providers. Therefore companies in low and middle-income countries engaging in new activities have no other choice to purchase from abroad.

Additional requirements

There are various ways of acquiring technology from abroad. Companies should be aware of the conditions of contract. Most companies would like copy, adapt and innovate the foreign technologies. Purchasing of equipment alone is not enough. The company needs also information to develop an understanding how the production technology can be adapted to its environment and modified to meet changing demands in the market. Thus firms should consider if they only want to purchase equipment or also need training, design information of the equipment, etc. When the firm already has access to such information and has the capacities to adapt and modify the technology, purchases of the hardware alone will suffice.

Generally speaking, sellers of technology will impose more restrictions with regard to technology modifications when the technology is relatively young and will be more cooperative to share drawings and technical information when the technology is outdated in their own advanced economies. Outdated technologies in the advanced economies may still be very appropriate in low and middle-income countries.

Companies aiming to expand production processes and replicate the original design at other locations, may wish to have its own managers and engineers participate in the design and construction of the production plants to obtain hands-on experience. This participation enables transfer of tacit knowledge.

If the company wants to move into the industry of developing and selling production technologies, it needs to ensure that its engineers and researchers participate during the design of the original.

Joint ventures

If companies need the latest international high-technologies they probably have to form a joint venture with a multinational. A joint venture goes beyond purchasing technology. It is merely a partnership between domestic and foreign parties. Both parties contribute capital, know-how, property rights, etc. Often the foreign parent company finances the major share of the technology transfer. Thus companies may obtain technology very cheaply. However the rapid technology transfer also comes at a cost. First of all joint ventures usually require government approval. Secondly the transfer of the technology may be dealt with like a loan, which will have to be repaid with interest from the returns. In addition the foreign company will withdraw parts of the joint venture profits and transfer them to the parent company. The repayment of the transfer not only relates to the hardware, but may also include know-how and patent rights. Intangible items which are hard to capitalise. The purchasing party and its host

government should therefore insist that the selling party disclose its figures and break them down with great detail. Alternatively purchasing parties in collaboration with host governments can increase their bargaining power through competitive bidding, exercising simultaneous negotiations with a number of interested companies.

Furthermore the purchasing company have to share ownership and loose control over the direction and function of the company. Many joint ventures fail because the involved parties have different goals with respect to the business and transfer of technology. The parties may have different demands with regard to the rate of returns, pay-back times and utilisation and development of technology. The parties may disagree with the direction of product and production technology development because they have a different geographical business focus. The buying party may wish to concentrate on the domestic market, often as a result of the license agreement that is part of the joint venture. This license agreement may limit the geographical scope. The Transnational Corporation clearly concentrates on its overall business interests and is often only partially interested in the particular developments of a specific joint venture. This means that the selling partner may divert product and technology development efforts towards its own interest and away from the interest of joint venture. The Transnational Corporation may also underinvest in R&D and favour other R&D activities. Continuation of payment of royalties may provide incentives to Transnational Corporations to make available newer technologies or introduce product modifications.

Even when the foreign investor does not take an equity share, it is still likely to manage and control the joint venture operation. The supply of technology, know-how, technical services, management and marketing expertise, patents and trademarks are all supplied and controlled by the foreign parent company. The domestic partner and the host government may consider imposing obligations to the parent company, e.g. setting up of research and development facilities and training of domestic technical and managerial staff, with the intention to appoint them on key positions.

Furthermore they may impose requirement with regard to the number of domestic directors on the board of the enterprise regardless of the equity contributions of the two parties. Alternatively they may require a structure that major decisions need approval from both the foreign and domestic partner. The government may also obtain decision power, concerning issues of national interest.

Licensing

Licensing is another alternative to obtain recent technologies. Although the owners do not loose control over the company, they only obtain full authority to adapt, modify and innovate the technology after the license expires. It is also difficult to make reliable assessments of many technologies that are not patented. These technologies are protected from copying by secrecy or kept uncodified.

Many license agreements have attached strings. For example, the licence may include monopoly rights to supply the licensees' products in a particular segment of the world market and prohibit any sales outside it. But other conditions may be attached to the licence as well.

Turnkey	Unless special efforts are taken, purchasers will not obtain technical information and understanding from turnkey projects. Companies may have to purchase additional packages to train its staff. But such training is not enough to develop in-house capacity to upgrade and innovate the technology. Reverse engineering is a proven method to obtain tacit skills and information about the technology.
Second hand equipment	Industries in advanced economies are eager to sell of their "outdated" equipment. But what is outdated in an advanced economy is often more than appropriate in low and middle-income countries. The problem is that often the production of spare parts has been stopped. Larger companies may be tempted to develop these spare parts themselves. Alternatively firms may develop partnerships with repair shops and firms specialising in reverse engineering to obtain all the maintenance capacities, including spare parts.
Small enterprises	Small-scale suppliers are often better providers in custom-made products and technologies than large providers. They have the flexibility to meet changing demands. However small suppliers and manufacturers are less consistent with regard to the quality of their products. In most cases they deliver excellent quality, but in exceptional cases the purchaser may be unlucky. In contrast most small providers are more service orientated

APPENDIX 1; OPTIMAL REPLACEMENT AGE TECHNOLOGIES

Suppose new or improvement equipment or a new technology to produce a product is introduced. How would you determine the optimal replacement age of your equipment? How do you determine the economic life of your equipment? The older your equipment becomes the higher its costs for operation and maintenance and perhaps even the lower its production.

Economic life The economic life has been reached when the complementary cost is higher that monetary value of the production in the same period.

New modified equipment Economic degradation of equipment usually accelerates when identical production items with lower costs are introduced on the markets.

Action 1: Financial evaluation If new production means are introduced the first step should a financial analysis comparing the two different production means. The Net Present Value and the Internal Rate of Return methods are methods, which will give you an answer on this question. If the new/modified production means results in higher yields/profit, step 2 will be to determine the optimal replacement age.

Action 2: 10 steps The below-described method compares the direct goodwill with the indirect goodwill of the current production means. Do the following ten steps:

1. Determine current market value of existing production means
2. Determine current production of existing production means
3. Determine the depreciation, and variable costs[1] of the new/modified production means
4. Determine variable costs per production unit of existing production mean
5. Step 3-Step 4
6. Multiply step 5 with production per year
7. Step 6 minus maintenance cost of particular fiscal year
8. Step 7 plus residual value at end of fiscal year
9. Determine indirect goodwill of step 8
10. If indirect goodwill higher than direct goodwill continue with the same exercise with the following years, replace in existing production mean in the year with highest indirect goodwill

An example Suppose production mean X has a technical life of 5 years. The new value is US$10,000 and the residual value at the end of its technical life is US$ 1,000.

[1] Variable cost: Incremental cost; increase in cost if the production increases with one unit.

Age (years)	Maintenance costs in that year (US$)
1	100
2	200
3	300
4	400
5	500

The interest is 4%. Production mean X delivers 1000 hours production per year. After two year a new production mean Y is introduced. The current market value of X is US$ 4000. The variable cost per production unit for X is US$ 6. The depreciation cost plus variable cost per production unit for Y is US$ 7.50.

Suppose one more production with X than replacement.

Production x additional depreciation	1000 x (7.5-6)	1500
Maintenance cost year 3	300	300
Total	1500-300	1200
	Residual value after 3 years	2975
Total	1200+2975	4175
Net present value	4174/(1.04)	4014.42

4014.42 are higher than 4000 thus repeat calculation.
Suppose two more years production with X.

Production x additional depreciation	1000 x (7.5-6)	1500
Maintenance cost year 4	400	400
Total	1500-400	1100
	Residual value after 2 years	2000
Total	1100+2000	3100
Net present value	$1200/(1.04) + 3100/(1.04)^2$	4019.93

4019.93 is higher than 4000 thus repeat calculation.
Suppose three more years production with X.

Production x additional depreciation	1000 x (7.5-6)	1500
Maintenance cost year 5	500	500
Total	1500-500	1000
	Residual value after 2 years	1000
Total	1000+1000	2000
Net present value	$1200/(1.04) + 1100/(1.04)^2 + 2000/(1.04)^3$	3984.86

3984.86 is lower than 4000, thus search with the year with highest net present value. (year 4, US$ 4019.93)