TECHNOLOGY AND DEVELOPMENT OF SMALL COUNTRIES

Thomas R. DeGregori*

SMALL TECHNOLOGIES FOR SMALL DEVELOPMENT

Technology and science policies provide some of the most difficult decisions for a small country to make. It is also an area of choice that holds considerable promise for development. The barriers are difficult because frontier research is so costly and the knowledge base for effective use of technology is so large, that it is difficult for small, poor countries to gain access, even when the efficient scale of utilization is not prohibitively large. It is promising because science and technology have demonstrated the capability of allowing countries to overcome limitations of economic backwardness and limited resource endowment.

For awhile, the belief was prevalent that smallness in technology was the answer to the problems of poor and/or small countries. Small was beautiful! Small was renewable and sustainable. Small was eventually seen as a solution to the economic and environmental problems of countries of all sizes. To some observers, the self-evident virtues of smallness were based on the principles of biology and physics [7] [8]. In the economy of the global village, there is no small country problem.

If the new technologies, be they called small, intermediate, appropriate, or alternative, had the potential that their most enthusiastic supporters claimed, then there would be little need for a conference such as this. In fact, though small, labour-intensive technologies can play a useful role in the development process, over-reliance on them intensifies problems of economic backwardness. These strategies for the use of technologies bore considerable similarity to colonial theses of dualism or to apartheid, even though the philosophical thrust was for greater equality and local self-determination. Few could argue with the goal of self-reliance, though the pursuit of it paradoxically had the effect of making countries more dependent.

Inherent in the thesis of alternate technology was the assumption of fixed, finite resources. Living within limits became the order of the day. Unfortunately, the conception of technology and renewability falters on its own assumptions. For if resources are fixed, then these constraints not only limit development, they foretell an inevitable decline. For the very theory of entropy that was used as a justification for small technologies

---

*Professor, Department of Economics, University of Houston, United States of America.

doomed civilization to certain decline. Entropy, as strictly interpreted defines an irreversible pathway from order to increasing disorder, and for energy and mineral resources from concentration and user ability to diffuseness and unusability. Recycling can never be 100% effective, and each turn of the cycle reduces resource availability. Population growth accelerates the decline, while stable or declining population postpones but does not prevent the inevitable doom.

China, a very large country, was used as an example of the potential benefits of thinking and acting small. In some respects, furthermore, communes and other rural units were still quite large, but they still were functional units that gave some sense of potential comparability to small countries. Smil writes of "a recent voguish trend in Western academic writings" about what was "China's everyday practice for two decades" [9, p. 17]. A cursory look at China's efforts in using an intermediate type of technology can be instructive both as to its potential benefits and its limitations. Advocates of alternate technologies have frequently used China as an example of the success of small technology despite the fact that the governing philosophy of China was expressed in the phrase, "walking on two legs." This meant developing both large, complex enterprises as well as simple projects in rural areas [10, p. 279].

In developing its energy sources, China used a variety of different technologies. Though not the first to use biogas (it was developed much earlier in India), China has used it more extensively than any other country. Not mentioned is the estimate that "a third of China's 7 million or so small biogas digesters are under repair"[3, p. 252]. China opened small earthen and rock dams for hydropower as well as for irrigation and flood control. Smil concludes that the "advantages of intermediate energy technologies for China are indisputable."

China is also known for its use of renewable resources and small technologies in other areas. In agriculture the stories are legion about the farmers gathering the night soil from the towns and hauling it back to the communes. In addition, China also developed small scale fertilizer plants to supplement the use of manure. The electricity generated by the small hydroplants was used to power small, rural industries. Many of these industries turned out cement used to line irrigation canals and small farm implements for agricultural mechanization. In all of these areas the technologies fulfilled the criteria established for appropriate technology. In addition to being small they used local resources, frequently renewable, and they used local labour and skills and were generally more labour-intensive than comparable technologies in developed countries.

However, useful and necessary these technologies were, and possibly remain, for Chinese economic development, they do have their limitations. For example, the small coal mines were not always economical. "The lifetime of many of the small mines was ephemeral," writes Smil, "and a large part of production was consumed in an equally ephemeral iron-making campaign. In fact, it appears that in many cases the human and animal energy necessary just to open, operate, and maintain the small mines surpassed actual energy yield". [10, p. 280] [12, p. 128]. The "ephemeral" ironmaking production refers to "backyard furnaces" which are hard to label as anything but a disaster.China has been moving towards opening larger, more capital-intensive mines [5, p. 94] [11, p. 19].

China has a long history of using manure in agriculture. Current use is very costly in terms of labour. Overall, at least 20 percent of total agricultural labour time (and often 30-50 percent) was absorbed in collecting, processing, transporting, and applying organic fertilizers, which made their use both inconvenient and expensive in areas where there was a seasonal labour shortage [14, p. 682]. Citing a Chinese economist, Rawski uses the figure of 30-40 percent of the "total amount of manpower and animal power expended in the whole year" [6, pp. 95-96]. Furthermore, contrary to popular belief in many areas, organic fertilizers are less efficient as nutrient sources than are the manufactured kind. "With organic fertilizers, it is difficult to obtain nutrient proportions that match plant requirements," writes Weins. "Since release rates are slow, it is impossible to insure concentrated release at appropriate periods of plant growth." Organic fertilizers are most effective with use in a regimen that includes chemical fertilizers. Use of organic fertilizers alone traps the user in a "vicious circle" that limits further development [14, p. 682].

China has received high praise for its innovative methods for small-scale manufacturing and the use of chemical fertilizers [4, pp. 94-101]. These small factories produce either ammonium bicarbonate or aqua ammonia, which have a nitrogen content of 16-17 percent, and 14 percent, respectively. This nitrogen content is much lower than that for ammonia urea. These fertilizers deteriorate rapidly and are difficult to transport [2, pp. 425-440]. It is understandable, then, that since 1972 China has been a major buyer of large, modern, ammonia urea fertilizer plants.

Even with the many advantages of small rural industries, large industries have the potential for greater productivity. Rawski found that "despite its capital intensity, Western industrial technology is so productive that it often maintains an advantage in cost as well as quality over the alternative methods, even when, as in China, the ratio of capital to labour costs is enormously higher than it is in countries for which the technology was originally intended" [5, p. 94]. The trend in China has been "consistently toward substitution of capital for labour." In some instances, capital investment per unit of output was greater in relatively small plants. Whatever the benefits of China's rural industries, "the capital-saving contribution of small plants is of little significance" [5, p. 44].

The small technologies used by China illustrate their inherent limitations. The assumption of finite resources is in fact self-fulfilling, and at a lower level than realized. For example, on the use of manure as fertilizer, there are two constraints that put a ceiling on expanded utilization. First, there would have to be more humans and/or animals to provide the manure. As China's current policy shows, more mouths to feed is not the way to get more food per capita. More animal manure would require dedicating more land to raining stock, and this would likely be counter-productive to growing more food. Second, given the large expenditure of human time and energy to gather and use the manure, there is a severe limit to how much more manure could be used, even if available. Of course, some of that constraint could be broken with mechanization, but that leads to the path of "non- renewable" resources.

From 1952 to 1977, grain production was able to grow at 2.3 percent per year, staying just ahead of population, which grew at 2.1 percent average. Increasing output in agriculture by increasing factor input had precisely the outcome predicted by economic theory: it diminished returns to factors. As Anthony Tang has stated, "unlike other agricultures characterized by dynamic technological productivity advances, growth in inputs outpaced growth in outputs, rising 131 percent, compared to 97 percent output growth. ...as a consequence, total factor productivity dropped 15 percent or 0.6 percent per year" from 1952 to 1977 [13, pp. 405-410]. The decline in factor productivity occurred in a context in which China was using selected modern components, such as research in seeds, as part of its overall developmental effort. Even with these elements in its overall endeavor, China recognized that they were reaching limits and had to alter their strategy to include more resource-creating modern technologies.

The recent performance of the Chinese economy has been astounding. Output and productivity have been rising at rates at least double if not triple those previously recorded for China. It could reasonably be argued that the small, appropriate technologies were an absolutely essential component of the transformation of the Chinese economy and established a secure base for the modern accelerated growth. True or false, it does not negate the thesis that the employment created by economic expansion predicated upon relatively fixed, fininte resources is not sustainable. Technique must be transformed into the dynamics of technology and resource creation.

Vaclav Smil sums up the Chinese experience with small technology in a memorable phrase: "The Chinese, the world's greatest practitioners of frugal smallness, discovered that small is useful but small is not enough."

TECHNOLOGY, RESOURCE CREATION, AND SMALL COUNTRIES

Countries that are small both geographically and in terms of population tend to be limited in the range of available energy, mineral and soil resources. If they are poor, moreover, it reflects both the lack of rich resources exploited by outsiders and the lack of internal ability to develop the resources that they have. The inability to develop domestic resources is often thought of primarily in terms of financial capital, which can be borrowed, instead of lack of intellectual and technical capital, which cannot be. Or, at least, intellectual capital cannot as readily and as completely be borrowed through consultants. The best way to obtain intellectual and technical capital is to acquire it permanently through the education of the population.

It is knowledge, ideas, skills, human ingenuity, intelligence, human capital, or whatever combination of these one wishes to use, that provides the means of escaping the resource trap both globally and for small countries. It is ideas, skills, and behavior that is the essential element in technology, and it is technology that creates resources. It is meaningless to speak of resources apart from technology.

If resources were fixed and finite, they were as predicted, increasingly more scarce. Their scarcity would be reflected in increasing price. In my book, I present massive data (derived from other authors) showing a continuing downward movement in the real price of food and mineral resources [1]. Also shown is the sustained increase in per capita food production. The very falling real prices for raw commodity exports has been a major concern and cause of complaint of third world nations, large and small alike.

The issue of small countries is not small technologies but what is the best way to gain access to the best in technology. For many technologies, the basic units of the most advanced and sophisticated are very small scale, scale-neutral and applicable to third world countries. Here we are thinking in terms of such items a micro-chips, agricultural techniques, and output from satellites. Unfortunately, the generation of these technologies is based upon scales of production and a large and sophisticated knowledge base beyond most poor countries, large or small.

The first item on the agenda, then, is cooperative action among small countries to generate the knowledge base for applied technologies. Current efforts to develop a United Nations biotechnology center is an excellent example. Unfortunately, it is only an example of what is being attempted and not an example of the many such activities that should be in progress.

The second area is negotiating sustained access to technologies that have become vital to the world economies and the small countries within it. To its credit, my country, the United States, has treated some of the satellites as a common carrier resource. Many countries have benefited from the output of these satellites in the form of maps and information. These have regularly been made available to users at a nominal fee and have had benefits for areas many times the cost to the user. Satellites for communication, whether information or mapping, are critical to small countries' development, and sustained access must be assured.

The third item on the agenda is to find ways of adapting sophisticated technologies to local needs. Research being done by the International

Labour Organization on blending technologies holds great promise. It avoids the pitfall of using technologies for which the minimum scale is too large for a small country. At the same time, it avoids reliance on low productivity, traditional technologies that have an extremely limited capacity for change and resource creation. The most sophisticated technologies from satellites to computers, from nuclear technologies to micro-chips, can play a key role in small country development if they are integrated with local technologies.

An important consideration in the use of any of the technologies is linkage of these technologies to the general advances in technology worldwide. For not only are modern frontier technologies resource-creating, they are the technologies that are experiencing the most rapid change and development. Users of these technologies have a dynamic, developmental potential built in. Realization of this potential is dependent upon communication systems, local knowledge capacity, and patent and other rights of access. This latter political dimension is, and has been, a top priority item for third world countries in their discussion of technology transfer. The desire has been for access to proprietary technology at affordable prices, and this is a legitimate concern.

Linkage to technological change presupposes a local knowledge base to exploit them. Too often in technology transfer we have confused the movement of hardware with technology. Presence or absence of hardware is not an indicator of technology transfer. To make a technology one's own, a country must develop an intellectual and skill infrastructure capable of commanding it. The resource-creating power of technology works best when people with knowledge of local problems also possess the knowledge underlying the technology. Investment in education and research is also an investment in technology and development.

REFERENCES

[1] DeGregori, T.R., A Theory of Technology: *Continuity and Change in Human Development,* Ames, Iowa: Iowa State University Press, September, 1985.

[2] Etienne, G., "Foodgrain Production and Population in Asia: China, India and Bangladesh", *World Development,* Vol. 5, Nos. 5-7, May-June-July 1977, p. 429; article reprinted in Radha Sindha (ed.), The World Food Problem: Consensus and Conflict, Oxford: Pergamon Press, 1978, pp. 425-440.

[3] Hall, D., "Signpost to a Sustainable World", *New Scientists,* Vol. 102, No. 1409, May 10, 1984, p. 42. Hall is reviewing Lester Brown et al., State of the World: 1984, New York, Norton, 1984, p. 252.

[4] Perkins, D. (Chairman), American Rural Small-Scale Industry Delegation, *Rural Small-Scale Industry in the People's Republic of China*, Berkeley, California: University of California Press, 1977, pp. 94-101.

[5] Rawski, T.G., *China's Transition to Industrialism*, Ann Arbor: University of Michigan Press, 1980, p. 94. See also Vaclav Smil, China's Energy, Achievements, Problems, Prospects, New York: Praeger Publishers, 1976, p. 19.

[6] Rawski, T.G., *Economic Growth and Employment in China*, New York: Oxford University Press, 1979, pp. 95-96.

[7] Rifkin, J. *Entropy: A New World View*. New York, Viking 1980.

[8] Sale, K., *Human Scale*. New York: Coward McCann & Geoghigan, 1980, and Jeremy Rifkin, Entropy: A New World View. New York: Viking, 1980.

[9] Smil, V., "Renewable Energies: How much and how renewable?" *The Bulletin of the Atomic Statistics*, Vol. 35, No. 1, December 1979, pg. 17.

[10] Smil, V., "Intermediate Energy Technology in China", in Neville Maxwello (e.), *China's Road to Development (*2nd ed.), Oxford: Pergamon Press, 1979, p. 279.

[11] Smil, V., *China's Energy: Achievements, Problems, Prospects*. New York, Praeger Publishers, 1976.

[12] Stavis, B., *The Politics of Agricultural Mechanization*, Ithaca and London: Cornell University Press, 1978, p. 128.

[13] Tang, A.M., "A Critical Appraisal of the Chinese Model of Development", in Carl K. Eicher and John M. Staatz (eds.), *Agricultural Development in the Third World*, Baltimore and London: The Johns Hopkins University Press, 1984, pp. 405 and 410.

[14] Weins, T.R., "The Evolution of Policy and Capabilities in China's Agricultural Technology, in Chinese Economy Post-Mao". (A compendium of papers submitted to the Joint Economic Committee, Congress of the United States, Vol. 1, *Policy and Performance*, Nov. 9, 1978, Washington, D.C.: U.S. Government Printing Office, 1978, p. 682.