BIOTECHNOLOGY AND IMPLICATIONS FOR TECHNOLOGICAL CAPABILITY BUILDING IN DEVELOPING COUNTRIES

Cetindamar, Dilek
Graduate School of Management, Sabanci University, Turkey

Carlsson, Bo
Department of Economics, Case Western Reserve University, USA

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Contents

Summary

After analyzing the potential implications of biotechnology for developing countries, this paper discusses how to build a technological system in developing countries by focusing on biotechnology. By comparing the experiences of developing and industrialized countries in terms of capability building for biotechnology, the paper highlights the characteristics of the main elements of biotechnology system, namely firms, institutions, and networks among firms and institutions. It seems that the success of developing countries in establishing capability in biotechnology is dependent on how well these countries build their biotechnology system, receiver competence, and networks.

1. Introduction

In the coming millennium, one of the primary challenges for developing countries will be to create new opportunities for sustainable economic development through new technologies, particularly biotechnology. This paper aims first to show how biotechnology can affect the development of developing countries and then to discuss how these countries can build technological capability in order to benefit from biotechnology.

Section 2 will highlight the importance of biotechnology for developing countries by summarizing the advantages and disadvantages of its applications. Then, Section 3 will examine three elements of biotechnology system, namely firms, institutions, and networks both in developing and industrialized countries. By using the results of this analysis, the final section will highlight some important issues in capability building for biotechnology. The conclusion will also summarize some policy guidelines for developing countries.

2. Biotechnology and Developing Countries

Biotechnology has been in existence for more than 3000 years, but the modern biotechnology, on which this paper focuses, refers to the scientific breakthroughs starting from the 1970s onwards in genetics and molecular biology, such as rDNA (recombinant deoxyribonucleic acid) and genetic engineering. As biotechnology is a generic technology, its impact covers a wide range of industries as well as agriculture. The literature highlights many advantages that biotechnology can bring to developing countries. Some of these benefits can be summarized as follows:

- biotechnology may be a potential source for the production of cheap alternative food and reusable materials.
- biotechnology methods can help to mine minerals which otherwise would have remained unreachable.
- biotechnology helps to clean up polluted areas and contaminated water or to counteract dangerous substances.
- biotechnology brings tremendous energy savings, since most biological processes take place at relatively low temperatures and more importantly, recycling of biomass and other waste reduces energy needs.
- biotechnology makes plants resistant to insects.
- new high value-added products may be produced by means of biotechnology.
- biotechnology improves the health of animals and plants which, in turn, can help to solve malnutrition and hunger problems.
- it may foster rural industrialization, since agricultural production becomes more efficient and adds more value. This may prevent migration of people to cities and solve the problems of overcrowding in cities.
- biotechnology may reduce the need to import certain items, such as chemicals, fertilizers, and energy. Through the reduction in imports, developing countries can save foreign exchange that may be used for other purposes.
- development of crops will require lower inputs of chemical fertilizers.
- biotechnology can improve health conditions, since 80 percent of the people living in developing countries (about four billion people) rely on plants as sources of drugs instead of formal health care systems.

Before proceeding further, it is necessary to define developing countries, since they exhibit a great deal of variety, ranging from least developed countries, such as Madagascar, to more advanced countries, such as Singapore. It is possible to define various categories by using different criteria. For example, the United Nations has categorized developing countries under three groups according to their income, low-

income, middle-income and high-income countries (see Table 1). This paper prefers a technological classification of developing countries, since its unit of analysis is based on technology. By considering the most basic classification, developing countries might be classified under the following four categories:

1. Countries having little or no technological infrastructure.
2. Countries having some research capacity in agriculture but virtually none in other sectors,
3. Countries having some agricultural and industrial research capacity.
4. Countries (such as South Korea, Taiwan, and Singapore) having a significant amount of technological infrastructure.

This simple categorization of developing countries shows us that the impact of innovation on employment may vary completely depending on the country's technological development. Despite the variety of potential benefits of biotechnology, the real impact of biotechnology on developing countries would appear to be in the area of agriculture, for several reasons. First, leaving aside the first group of countries that have no technological infrastructure, the majority of developing countries have agricultural technology to some degree. Even though some countries have a weak technology base, for some developing countries it may still be possible to build a biotechnology industry by strengthening their existing agricultural research capacity.

Second, considering the industrial structure in developing countries as shown in Table 1, the less developed the country, the more agricultural its economy will be. The employment in agriculture for low-income economies constituted 69.0 percent of all employment in 1997; the corresponding share in high-income countries was 4.5 percent. The value-added share of agriculture for low-income countries is also high; namely 28 percent of total Gross National Product (GNP), while this figure is only 2 percent in high-income countries. Therefore, any improvement in the agriculture sector will improve economies in developing countries. In that regard, the expected biotechnology applications on agriculture are very important for them.

Country Groups	Population 1997	GNP/ capita 1997 ($)	% Agr. Emp. 1980	% Agr. Emp. 1997*	% Man. Emp. 1980	% Man. Emp. 1997*
Low-income economies	2 036	370	71.0	69.0	11.1	13.1
Middle-income economies	2 857	1 893	56.6	52.5	20.6	20.5
High-income economies	827	27 628	8.0	4.5	35.1	26.7
World	4 430	6 541	52.3	48.4	14.8	19.2

*Average for the 1990-1997 period.
Man.- Manufacturing; Agr. - Agriculture; GNP - Gross National Product.
Source: UN World Development Tables, 1999.

Table 1. Population, GNP per capita, Share of Agriculture and Manufacturing in Total Employment in Each Country Group (1980, 1997).

Third, developing countries own the majority of the plant genetic resources, which are raw materials for genetic manipulation. These countries are in tropical and sub-tropical areas, such as Central America, the Andean area, the Mediterranean basin, Africa, Central Asia, the Near East, and the Indo-Malaysian region. The rich genetic heritage is an advantage for developing countries to establish biotechnology industries.

Fourth, unlike other generic technologies, such as microelectronics, biotechnology is not highly capital- and scale-intensive, at least during the initial stages of development. For example, it is estimated that a tissue culture lab with a personnel of 15-20 researchers, which clones, develops and multiplies imported tissue cultures, may cost around US$20 000 to set up. Also, research costs are lower in developing countries than in industrialized countries because of lower salaries and wages and the low costs of inputs. However, it is clear that the more complex the biotechnology (such as genetic engineering), the more expensive it becomes.

Finally, if developing countries do not develop biotechnology in-house, they may face several problems. First, they need to direct biotechnology research and production to solve their own unique problems; otherwise the development of biotechnology in industrialized countries alone may follow different paths and may not solve the problems of developing countries. For example, 2/3 of drug research and development (R&D) in the USA goes to applications catering to the needs of the oldest segment of the population, while less than 3 percent goes to tropical-disease prevention or cure. However, the rate of infant mortality in developing countries is assessed at 20 percent, and hundreds of millions of children are infected by parasitic organisms. Second, there is a danger of a substitution effect. It is known that industrialized countries have started to produce some products in their laboratories, such as sugar-substitutes. In the long run, many products that have been imported from developing countries could be produced in industrialized countries. This will lead to trade reversal and could significantly affect the trade balances of developing countries. For example, the high fructose corn syrup produced from maize threatens the livelihood of 50 million workers engaged in the sugar industry of developing countries. Third, developing countries cannot benefit and influence the international research programs where they cooperate with industrialized countries. Many studies have shown that the researchers of industrialized countries mostly determine these programs. Similarly, standards and regulations are going to be designed by industrialized countries, unless developing countries have the knowledge and experience in biotechnology required to intervene and affect the international regulation of biotechnology R&D and applications. The last problem is related to technology transfer issues. The increasing intellectual property rights and protection in industrialized countries in the area of biotechnology indicate that technology transfer will become difficult, and in some cases impossible, for developing countries. In summary, if developing countries do not invest in biotechnology, then they may never benefit from the fruits of biotechnology. Instead, they may suffer from trade losses and from being left behind in such a critical technology.

However, it is important to keep in mind that even if developing countries invest in biotechnology, the success of biotechnology applications is not guaranteed, for the following reasons:

1. Biotechnology research is still largely experimental, and therefore unpredictable and uncertain.
2. It is a new and highly competitive technology. For example, the top two agrochemical and animal health companies spent $300 million on biotechnology in 1990, while developing countries altogether spent less than this amount.
3. Privatization of scientific knowledge is very high.
4. In many developing countries, there are no domestic consumers of research results, since the related industries may not exist in the market, or the results may not be cheap enough to replace traditional agricultural methods.
5. There is a shortage of major equipment in the research sector.
6. A revolutionary change should not be expected, since even though there are about 500 companies and 150 research organizations related to plant agriculture in the world, only a few transgenic plants exist in the market (e.g., the Flavr Savr tomato, which has been on the market since 1994.
7. The applied research units in the industrial sector do not exist in many developing countries.
8. Some inputs, such as rare chemicals, are in short supply.
9. Many institutions and new disciplinary capabilities related to the development of biotechnology are absent and need to be built.

Moreover, not only developing countries, but also industrialized countries, face problems in developing biotechnology. A study of the US biotechnology sector shows that even though R&D expenditures increased in the 1980s, the applications to the United States (US) Food and Drug Administration to market new drugs dropped some 60 percent. Another study indicates that, in 1999, there were 1283 biotechnology firms in the US spending $9.9 billion in R&D, with sales of $13.4 billion and a net loss of $5.1 billion.

Therefore, developing countries need to take into consideration these problems and form more realistic policies for their biotechnology development on the basis of a technological system. In other words, they should build capability by setting up the networks that support the development, diffusion and utilization of technology in biotechnology.

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Biographical Sketches

Dilek Cetindamar (Ph. D., Istanbul Technical University) is an Assistant Professor at the Graduate School of Management at Sabanci University (Istanbul, Turkey). Previously she worked as a research associate at the Weatherhead School of Management at Case Western Reserve University (Ohio, US), the Department of Industrial Dynamics at Chalmers University of Technology (Gothenburg, Sweden), and the Department of Engineering and Technology Management at Portland State University (Oregon, US). She has published several articles in industrial economics, technology systems, and development issues.

Bo Carlsson (Ph. D., Stanford University) is Associate Dean for Research and Graduate Programs and William E. Umstattd Professor of Industrial Economics at the Weatherhead School of Management, Case Western Reserve University (Cleveland, Ohio). Previously, he was a Research Associate and Deputy Director of the Industrial Institute for Economic and Social Research (IUI) in Stockholm, Sweden. Bo Carlsson has published several books and numerous articles in industrial economics, long-term industrial development, small business economics, and industrial policy. Since 1987, he has been the director of the research project "Sweden's Technological Systems and Future Development Potential" involving four leading research institutes in Sweden.