Chapter 8.8
Technological Change and the Transformation of Global Agriculture:
From Biotechnology and Gene Revolution to Nano Revolution?

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ABSTRACT

This chapter discusses the economic impact of science-based research in agriculture. Global agriculture was transformed in the 20th century by the Green Revolution that resulted from applying Mendelian genetics to crop and animal breeding. Developments of biotechnology in the last 20 years marked the dawn of a gene revolution that is thought to replace Mendelian genetics as the driver of technical change in agriculture. In recent years and still far from reaching the full potential impact of biotechnology in agriculture, developments in nanotechnology promise to further push the research and innovation frontier in agriculture. In this new environment, the private sector emerges as the main actor in agricultural R&D displacing the public sector, which played a central role during the Green Revolution period. However, more public investment in R&D rather than less and new institutions will be needed in developing countries if they are to benefit from the new technologies.

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INTRODUCTION

The need for agricultural growth during the early stages of development has been at the center of debates in the development field. In early classical economic theory, agriculture was characterized as a sector with low productivity, traditional technology and decreasing returns, a sector that only passively contributed to development by providing

food and employment. Because of being dependent on a fixed amount of land it was assumed that agricultural output couldn't increase proportionally with increases in labor supply under a given technology. On the demand side, and because agriculture was seen as the sector providing food for the satisfaction of basic needs, it was assumed that it was not possible for agriculture to grow faster than population in order to avoid stagnation in a Malthusian trap. In contrast with this view of agriculture, manufacturing appeared under the eyes of the early growth theorists as the sector with high productivity and increasing returns.

In part, this view of agriculture was based on the constraints that some of the specificities of agricultural production imposed on growth. Firstly, production in agriculture deals with live organisms and unlike any other sector in the economy it involves land as a key factor of production. The importance of land in agriculture introduces rigidities into the production process and strong interactions with the environment. For example, some of the production activities are seasonal, which determines that the demand for labor concentrates at a certain time of the year, with other periods where resources stand idle. The biological nature of agricultural production and its interaction with the environment also introduces a high degree of uncertainty on the final results of the production process. Secondly, and because land and live organisms are an integral part of agricultural production, the interaction with the environment makes this production process dependent on agro-ecological conditions, which are specific to a particular geographic location. Thirdly, the importance of land also introduces space-related economic factors affecting production decisions like the location of land with respect to markets, transportation costs for inputs and outputs, and infrastructure. All these factors affect the spatial allocation of production of different crops and livestock activities. Lastly, land as a factor of production brings the space dimension into the production process at the farm level: machinery, unlike in manufacturing, needs to move to the production site introducing new costs and technical challenges.

The view on the role of agriculture in the economy started changing with the transformation of the agricultural production process through the introduction of science-based technology. Early advances in mechanical and biological technologies showed that constraints in land or labor endowments could actually be overcome by fostering the links between science, agriculture and manufacturing. It was also found that agricultural growth could be transmitted to the rest of the economy through linkages with other sectors, for example, through a growing and cheaper supply of inputs to manufacturing, or by providing more and cheaper food to urban workers. Recent studies go beyond these linkages showing positive relationships between nutrition and economic growth, between enhanced food security and growth and between agricultural growth and poverty reduction.

As mentioned above, the potential impact of agriculture on economic growth and development was recognized when technological advances were incorporated in the production process. In fact, it was the development of science-based technologies that allowed the transformation of agriculture overcoming constraints like the fixed supply of land that were thought to impose rigid limits to agricultural growth. At present, the mainstream agricultural production methods and technologies that are being applied are the result of Mendelian genetics. The growing number of applications and developments of biotechnology applied to agriculture in the last 20 years marked the beginning of a new era in agricultural research. In recent years and still far from seeing the full potential impact of biotechnology in agricultural production, developments in nanotechnology offer to introduce changes in agricultural research and innovations that are as large as those promised by biotechnology 20 years ago, if not larger.