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Per Capita Income Growth and the Nature of the New Technologies: Implications for Agricultural Research

The role of intellectual capital in the growth of agricultural production

Over 200 years ago, in 1798, Thomas Malthus predicted that while food production grew mathematically, population grew geometrically and because the second grew faster than the first, the time would come when food production would not be enough to feed the population.

Today we know that Malthus' prediction was incorrect. For example, during the last 40 years, per capita food production worldwide grew 25%, land used for agricultural purposes increased by 10% and world population soared by 90% (The Economist, March 25-31,2000). Because of the nature of the current world economic and social system, not all the world's inhabitants benefit from this growth in food production.

Where was Malthus wrong? The answer, technological change, is easy for us to see now although perhaps it wasn't in his time. In fact, the main contribution to economic growth does not come from an increase in the physical inputs of production, as Malthus perhaps viewed it, but rather from the application of knowledge to generate value. This so-called intellectual capital is what enabled agriculture in the 20th Century to bring crop yields and total factor productivity in agriculture to unprecedented levels.

After World War II, this intellectual capital brought about the "Green Revolution," which involved new biological, chemical, machine and organizational types of technologies. Since then, productivity gains have reduced the prices of agricultural products (in real terms) or at least their growth rate.

Some implications of per capita income growth

By the end of the 20th Century, per capita income, in real terms, had increased steadily in the high- and low-income countries (Antle, 1999). This trend was particularly evident during the past 15 years in the countries of Latin America, with the exception of Bolivia, Nicaragua and Peru (IDB. Economic and Social Progress in Latin America. Reports: 1995, 1998-1999). Growth in per capita income leads to a reduction of the share of the agri-food sector in the economy because, in large part, foods are normal goods *[1]* . In other words, as per capita income grows, the proportion earmarked for food consumption contracts, leaving a greater share of income for the consumption of other goods.

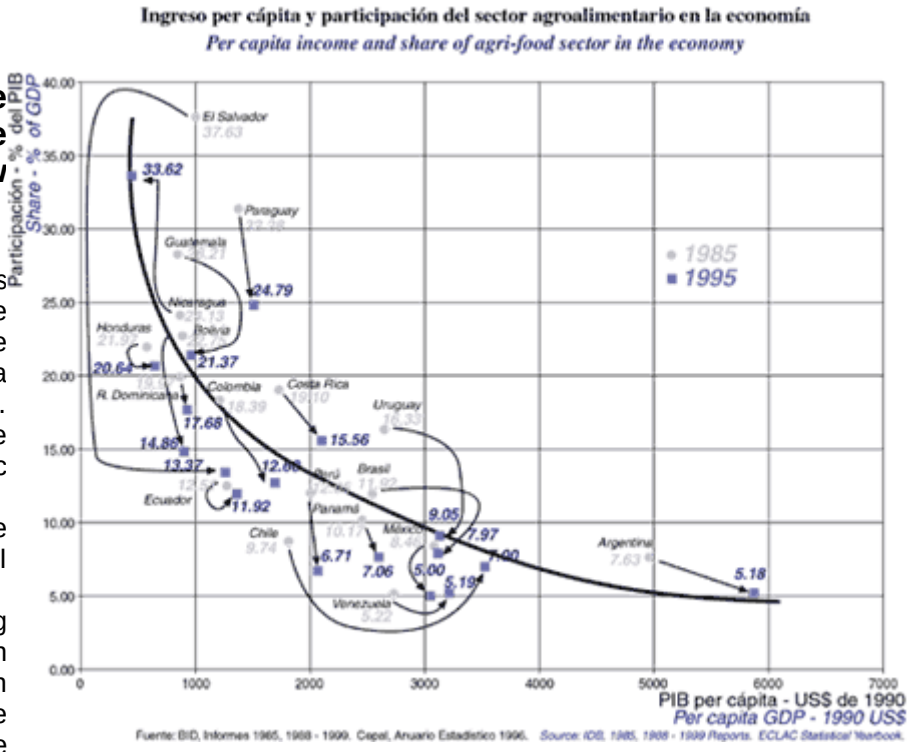
The relative greater demand for other goods stimulates growth in other sectors of the economy, such as durable goods and services. In fact, the share of the agri-food sector in the economy is declining in the more advanced countries as well as in Latin America and the Caribbean (as suggested in figure 1), and it is likely that this trend will continue for some time into the 21st Century.

Other important implications of per capital GDP growth include: a) increases in the opportunity cost of consumers' time, which boosts the appeal of processed foods or food consumed outside the home; and b) a demand for greater quality in agricultural products and differentiated products.

Consequently, it is likely that there will be greater demand in higher-income countries and Latin America and the Caribbean (LAC) for quality agricultural products and processed

products produced at different points in the agrifood chain, distant from the farm gate and closer in the production chain to the final consumer -as compared to traditional and unprocessed products (Antle, 1999).

The characteristics of knowledge and the nature of the new technologies



In many of its forms, knowledge can be characterized as a public good [2] . In practice, there are no pure public goods. Nonetheless, some of the biological technologies developed during the Green Revolution - which accompanied the economic cycle spurred by the "wave" of petrochemical, electronics and aviation technologies of the 1950s-1970s - can be characterized as public goods. A stated reason used to justify State provision of public goods is that there are no incentives for the private sector to produce them because, once available to one consumer, they are also available to others at no cost, because they cannot be excluded.

Therefore, the provision of public goods by the private sector is less than the social optimum, and was the argument given in Latin America and other parts of the world to justify State intervention in agricultural research and development (R&D) during the 1960s and 1970s, when public national agricultural research institutes (NARIs) were established in most of the countries of the Region.

In the 1990s, however, a new pattern of economic growth emerged primarily in the higher-income countries, based on the services and information and spurred by the new "wave" of semiconductor, fiber optic, software and communications technologies. In this setting, the field of biotechnology is expanding rapidly, especially because it combines knowledge of genetics with the knowledge of the chemical, pharmaceutical and seeds industries to produce genetically modified, or transgenic, organisms (GMOs).

In some cases, the value of the intellectual capital generated by the new biotechnology throughout the production chain can be captured, either by creating a partial monopoly with the legal instruments available for protecting intellectual property (patents, contracts, licenses), by controlling supply (vertical integration or joint ventures) (Jolly and Lence, 2000), or simply by default, because it is costly to decipher the production process in order to replicate the given products. In these cases, businesses have incentives for investing in R&D and recovering large investments in biotechnology, despite inherent risks.

In the new phase of economic growth, many of the technologies generated by R&D are really "semi-public goods" (Cap, 1998): consumption by one agent does not reduce the value for another but agents can be prevented from consuming it (through the aforementioned

mechanisms). Even NARI-developed technologies are not always public goods but rather "semi-public goods" because the cost of adapting and adopting some of them prevents some producers from using them.

Changes in the composition of investments in agricultural research

It is a fact that the rate of growth in public investment in agricultural R&D is falling worldwide. In Latin America and the Caribbean public investment in R&D is falling in real terms (Alston, Pardey and Roseboom, 1997). Although this situation has been turning around recently in the United States of America, funding sources are changing. Since the 1990s, the share of private investment in agricultural research in the United States has been growing, and the intellectual property regime for living organisms has been strengthened in that country.

Final observations

For the reasons given above (increased per capita GDP in high and low-income countries; a likely increase in demand for quality and processed products; changes in the nature of biological technologies; strengthening of intellectual property rights), it is likely that private sector investment in agricultural R&D will continue to climb. A recent example of the potential of such technologies in Latin America is that in 1999, Argentina had 16.8% of the world's area planted to transgenic crops.

It is unlikely, however, that LAC public investment in R&D will increase in real terms in the short term; an increase in joint ventures among the private, public and university sectors to meet the demand of specific market niches for quality, differentiated product is more likely.

Nonetheless, so long as the market can make sure that private and some semi-public goods are produced, public sector investment in R&D should place greater emphasis on producing technologies that can be characterized as public - and environmentally friendly- goods for small-scale producers and for satisfying the food needs of the poorest sectors of the population.

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[1] Their elasticity with regard to income is less than one.

[2] A public good can be defined by the following two characteristics: 1) use of it by one agent does not diminish its value to another agent, and 2) no one can be excluded from consuming it. An example would be the light given off by a street lamp.