BIOTECHNOLOGY AND THE STRUCTURE OF AGRICULTURE IN DEVELOPED COUNTRIES

A Comment

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Abstract

Applications of biotechnology are expected to have little effect on the economies of scale in agriculture. Diffusion will be slow. Although applications of biotechnology will gradually increase, in particular in science and technology programmes, in input-producing and processing industries, they are still unlikely to cause a break in prevailing trends of structural and economic development of the agricultural sector in the next 10 - 20 years.

Introduction

Modern biotechnology[1] makes headlines. It fills a significant share of the columns of journals and magazines. It receives hugue research budgets from governments and private business. It is regularly on the agenda of politicians, research administrators, interest groups and professional organizations. It arouses heated debates about its possible benefits, its risks, its impact on economy and society and its ethical aspects. Some people see it as a likely bonanza, others as an alchemist's dream and some fear it is Pandora's box. Some have great expectations of the spread of benefits of biotechnology, others fear that it will enhance dictatorship by technocrats and monopolistic power of multinational corporations. In some views biotechnology offers great opportunities for agriculture, whereas opposing views expect it to have as a result that agriculture will become a dependent part of big agro-chemical, pharmaceutical and food processing companies. Quite obviously, this is the kind of issues that make headlines.
This paper pursues the question what impact biotechnology is likely to have on the structure of agriculture and related sectors in developed countries in the next 10 to 20 years.

How to assess the impact of modern biotechnology on structural change

The question how biotechnology affects prevailing trends has several methodological aspects. In the next chapter the question will be discussed what kind of technology biotechnology is and how it is related to science and other technologies? Here the issue of impact is discussed.
The agricultural sectors in the developed economies have experienced tremendous structural change over the past century, in particular in the period since World War II. Many factors are contributing to that change and there is no reason to expect that without biotechnology this trend would change drastically in the next 10 to 20 years. The question about the impact of biotechnology is in fact whether it will change prevailing trends. This requires an assessment of the case with and the case without.
The concept "structure of agriculture" refers to such issues as: the relation of factors of production within farms, the size distribution of farms, their characteristics of production and productivity, and their relations with supplying and processing sectors. Changes in the structure of agriculture are the effect of

many factors such as technical change, social and institutional change and changes in the price structure. Changes in productivity are also closely related to changes in structure.
Trends in agriculture over the past decades can be characterized as follows[2].
Since the Second World War labour productivity in the agricultural sectors of developed countries, with the notable exception of Japan, has increased more rapidly than in industry and services (Van der Meer and Yamada, 1990). In general the same was the case for net factor productivity. Since demand for agricultural products grew only slowly the agricultural sector inhibited a persistent tendency for excess capacity and excess production and faced pressure on prices and income. In many cases price support given by governments to mitigate the depressing effect on incomes resulted in over-production. The major factor contributing to total productivity growth was the rapid decline of labour input. Although agricultural research is mainly devoted to achieving yield increases and biological efficiency the effect of these improvements on total productivity is usually much less than that of the decline in volume of labour. Despite of its rapid development the agricultural sector still largely consists of small independent farms, operated by a farm family, which employs none or only a few paid farm labourers. Farm sizes have increased but beyond the sizes of the biggest ten to twenty per cent of the farms economies of scale are limited. And although farms are small and often engaged in one or another form of contract farming they still have much freedom in their choices.
An assessment of the impact of biotechnology on these characteristics and trends is difficult to give. There are often conflicting expectations and speculations about technical possibilities. An assessment of the likely economic and structural impact is even more difficult. It is after all the producer and the consumer who will decide. Economists are better at explaining the past than at predicting the future. So what can economists contribute to all the claims about biotechnology? One useful contribution can be to discuss biotechnology in the light of experiences with technological change, growth of output and productivity and structural change in agriculture, and to make conditional statements about the possible impact on present trends. Not only attention should be given to direct effects on the structure of agriculture by applications of biotechnology in the agricultural sector itself, but also to indirect effects which can result from applications within research and development programmes and within input supplying and product processing industries.

Impact of biotechnology in research and development

Biotechnology is a generic technology which means that it has a large number of possible applications in many fields. There are many similarities with for example electricity, information technology and chemistry. When genetic codes were deciphered and techniques for modifying genetic properties were developed it was very useful to bring this kind of research together in special programmes, but gradually applications have become integrated within other research programmes. This implies for example that knowledge of genetic codes accelerates and enhances effectiveness of traditional breeding programmes. Similarly it may help all kinds of research by developing better detection methods. In other words some tool, just like electricity or chemistry has been added to the existing tool set of the researcher. On the other hand, by its very nature research and development in the field of biotechnology requires a fairly advanced general research infrastructure. If such a broad base is not available research in biotechnology is probably rather ineffective and inefficient.
All this together has two implications. First, it means that biotechnology is not an appropriate technology for countries that have not yet built up a good research system. Second, since it can only properly function jointly with other

research the estimation of the return to investment in biotechnology research is difficult to isolate and in most cases therefore overestimated by its proponents.

Impact of applications within agriculture

How should the techniques that together form biotechnology be characterized from a point of view of agriculture? In the literature of agricultural development usually a distinction is made in land saving and labour saving technologies. The former consist largely of biological and chemical techniques and the latter mainly of mechanical techniques. Although in practice a clearcut distinction is not always possible since some techniques exhibit characteristics of both, the distinction is important for conceptual reasons. Green revolution technologies, i.e. use of high yielding varieties, fertilizers and water control, are a typical example of land saving technologies. Tractorization is an example of labour saving technologies. Comparative research shows that land saving technologies are most important in situations of land scarcity and at a lower level of economic development, whereas labour saving technologies are important in land abundant and labour scarce situations and in advanced economies (Hayami and Ruttan, 1985). In general land saving technologies are scale neutral, whereas labour saving technologies are characterized by economies of scale. Both types of techniques are to some extent embodied in purchased inputs, but they usually require farmers' knowledge for succesful application. This knowledge can be obtained from other farmers, extension workers or from education.

Biotechnology-techniques that can sooner or later be applied in agriculture seem to be typical examples of biological and chemical techniques: modified properties of products, resistance against diseases and better technical input output relations. They are not likely to have significant economies of scale. From this perspective therefore no change in the pattern of agricultural development is likely. However, the possible impact of biotechnology does not only depend on the characteristics of the technologies but also on the pace and the intensity by which they are becoming available.

Although biotechnology applications are likely to become more important in the next 20 years it seems unlikely that they will exert a strong effect on the pace of technical change. There are several reasons for this.

First, the commercially viable bio-techniques are emerging slowly because of technical and financial obstacles. It should be expected that for most products it may take quite some time before genetically modified and commercially attractive varieties will become available. This is a general experience with generic technologies such as electricity and information technology (OECD, 1989, Ch. III). The diffusion of genetically modified varieties in agriculture is likely to take quite some time as well. Genetic modification of micro-organisms is technically easiest and therefore likely to result in significant applications first. But the applications will be made mainly in industry not in agriculture. Genetically modified plants will have more impact on agriculture but developments in this field are slower because they are technically more complicated. Applications of biotechnology on animals are still more complicated than on plants.

Second, in several cases biotechnology applications may be technically possible but still less cost effective than traditional breeding techniques.

Third, if the present GATT negotiations result in liberalization of markets and decoupled income support then in most of the developed countries prices will decline. This will make yield-increasing technologies less attractive and probably slow down the pace of land saving technological change in countries that have at present relatively high price levels.

Fourth, there are risks and uncertainties about safety of applications for health and environment, which can most likely be dealt with, but which will initially increase costs and result in lengthy and sometimes complicated procedures for ad-

mission.
Fifth, opposition to biotechnology seems firmly rooted in different groups. There are ethical questions about applications of biotechnology, in particular for animals. Among some fundamental Christian groups the ethical belief is wide-spread that genetic manipulation is perhaps not within the range of acceptable activities towards nature and life. Among ecologists and environmental groups many see biotechnology as a dangerous and undesirable set of tools that is better not to be used, i.e. the earlier mentioned box of Pandora. Among political activist groups on the left there is much opposition against biotechnology, which can perhaps best be understood as a continuation of an age-old movement against capitalist development and the role of technology in a capitalist world[3]. Since the industrial revolution there were continuously objections against new techniques. In most cases in recent history, however, ethical and political objections gradually disappeared or were overruled. This may also turn out to be the case with biotechnology, but it is also possible that there will remain a strong opposition against genetic manipulation. In this respect there are likely to be significant differences between countries, such as at present is already the case between countries in south and northwest Europe.
Sixth, consumers acceptance, which is partly related to both previous points, is still far from certain. The attitude of consumers toward food has changed significantly during the past decades. If, for example, products produced by biotechnology, have to be labeled then some of them may receive a discounted prices, which partly offsets the potential productivity benefits for producers.

These points still exhibit many uncertainties and there may be significant setbacks in the rate of adoption of biotechnology. But, even if everything is going smoothly the rate of application of biotechnology within agriculture may still be slow in the next 10 to 20 years. The net benefit of applications is the difference between value added of the with and without case. In practice benefits seem often much over-estimated. Claims by biotechnology lobbies are sometimes exaggerated in the sense that they suggest high market shares for biotechnological products and incorrectly equate the net benefits to the share in value of production. Moreover, as argued already increases in total productivity are more dependent on decreases in labour input than on biological efficiency. So, from an economic point of view it seems realistic to have only moderate expectations about the net economic benefits of biotechnology in agriculture in the next 10 to 20 years.

Impact of applications in input supplying industries
The agricultural sector obtains considerable amounts of imputs from supplying industries. In developed countries these inputs amount to often more than 50 per cent of total value of production. The quality and price of inputs forms a crucial factor for international competitiveness of the agricultural sector. Biotechnology is mainly applied in pharmaceutics, plant breeding and propagation and animal breeding[4]. The concerned parts of these industries form in quantitative sense only a modest share of the total input in farming. Nevertheless, there is much concern that agriculture will become fully dependent on a few multinational corporations in this field, because of the increasing role of concentration, patents and plant breeders rights. Fact is that since the middle of the 1970s there have been many mergers among seed companies. This was related to the increasing economies of scale in this branch as well as to the fact that the oil crises in the 1970s stimulated interest in utilizing renewable resources, not in the last place among oil companies. However, the prospects for producing bioenergy and non-food applications are dim now and returns have been below expectations. In one recent case in the Netherlands an oil company sold a seed company

to an agricultural cooperative and informed sources claim that this is not an isolated case.
Yet, there is a persistent strong concern among part of the farmers and in particular among third world activists and radical groups to the left that farmers and third world countries are becoming dependend on breeders rights and patents and that they may be exploited by multinational companies. These groups have little confidence in the role of competition and in the countervailing powers. There is certainly over-sensitivity with respect to seed companies, which can be illustrated by the fact that the world market for chickens of layers and broilers is served by hardly a dozen companies and that of four-wheel tractors by even less. There are also few pharmaceutical companies left.
The present sentiments about dependence on seed companies seem to be a continuation of those voiced by about the same groups with respect to the green revolution. Not rarely in debates these groups still refer to "the failure of the green revolution" when talking about the possible adverse effects for farmers of applications of biotechnology by seed companies.

Impact of applications in processing industries
In the processing industry biotechnology is likely to be applied on a significant scale both in food processing and processing for non-food applications. In processing of agricultural products two developments that are already taking place, could be accelerated by biotechnology. First, there is a trend by which farmers are encouraged to produce certain products at carefully specified conditions. This has resulted in various forms of sub-contracting. Diversification in consumer markets partly results in diversification of demand for raw materials. Some people, and in particular critical groups mentioned above, believe that these developments will make farmers more and more dependent on big companies and that the application of biotechnology will strengthen this. Second, industries are continuously looking for possibilities to substitute expensive with cheap raw materials and they have been succesful in doing this. It is assumed that biotechnology will enhance this process. This is often marked as a negative impact of biotechnology on agriculture since it forces agriculture to compete with synthetics and it also introduces competition among groups of farmers who previously produced for separate markets. It is believed that as a consequence total value added will decrease. Artificial sweeteners and substitutes of vegetable origin for dairy products are the most cited examples.
Although changes in the processing industries induced by applications of biotechnology can have negative effects for particular groups, there are positive effects as well and, therefore, the view that stresses negative effects only is rather superficial and biased. It ignores the consumers interest, it fails to see the relation between substitution and protection in the sugar and dairy markets and it narrowly focusses on some selected effects of some processes without considering the wider impact of processes of technological change and economic development. One particular future contribution of biotechnology to the competitiveness of agriculture could be that plants and animals can become new or more attractive sources of special chemicals, or that their products can be better processed. Such developments could enhance competitiveness of some branches of agriculture. In that case agriculture becomes more differentiated.
The dependence of farmers can not be properly understood if not the dependence of processing industries is taken into consideration as well. Once processing industries have invested in certain products they depend on reliable supply of raw materials at good quality. So there is usually a mutual dependence of farmers and processors and it is likely that this dependence will become of increasing importance for the competitiveness of agriculture. Probably, the presumed independent traditional bulk producing farmers are more dependent on powerful outsiders than

the well-educated and properly organized groups of modern farmers.

Footnotes

1. Some definitions of biotechnology are very broad and include all traditional uses of biological processes. In this paper a more narrow definition is applied. Here biotechnology refers to the collection of techniques which use knowledge of genetic codes and genetic modification, in particular by recombinant DNA-techniques and cell-fusion.
2. For a detailed discussion of growth and development in agriculture see Van der Meer and Yamada (1990) and Van der Meer (1983 and 1989).
3. From an economic point of view an interesting review is found in Kitching (1982). Van der Pot (1985) has given a broad overview of schools of thought from a philosofical perspective.
4. To some extent it is applied in the feed industry as well. In the Netherlands additives are used to reduce the phosphate content in compound feed in order to reduce environmental problems in areas with intensive livestock raising.

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