THE ECONOMICS OF AGROBIOTECHNOLOGY

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Contents

Summary

The development and application of agrobiotechnology has important implications for the organization of research, the economics of agriculture production, and consumer welfare. The role of public-private partnerships in research will become more important in the future and will challenge the independence of public research. The concentration among the life-science companies through mergers and acquisition has to be observed closely to avoid excessive use of monopolistic power. This will be of special concern for regulators, as they have to weigh the gains through patents against the welfare losses of restricted monopolies.

It is still uncertain if consumers will accept food products made from transgenic crops (see also– *Why genetic modification arouses concern*). Experiences in the US with BST-milk suggest that negative labeling may be a solution and create niche markets.

Until now, one of the major problems in the economics of agrobiotechnology is the assessment of benefits and costs and their distribution along the supply chain. The nature of the problem demands analytical methods that have only been developed recently. The incorporation of irreversibility and uncertainty allows researchers to recognize the risk associated with the release of transgenic crops into the environment at the theoretical level. Some important progress has been made recently.

1. Introduction

Agrobiotechnology challenges the political economy of agriculture in many countries. Never before has a new technology in the field of agriculture been so emotionally debated among different stakeholders. Developing countries' scientists fear to be bypassed by the new technology, while at the same time groups of consumers, politicians and non-government organizations (NGOs), both in developed and developing countries, oppose the introduction of transgenic crops (see also - *Transgenic plants*), which they see as a threat to biodiversity, human health and the economy of rural communities, ultimately endangering sustainable development. Radical groups go as far as destroying research plots and laboratory equipment. Especially in Western Europe, many people have lost their confidence in modern science because of the BSE scandal, HIV-tained blood and other such incidents. Consumers are further disconcerted by the disagreement among scientists about the environmental and human health impact of transgenic crops (see also - *Why genetic modification arouses concern*). While some highlight the potential risks, others argue that they are negligible.

However, much of the discussion on the risks and benefits of agrobiotechnology is based on ideologies and beliefs. Scientific evidence about long-term effects is scarce, and economic analyses are at a very initial stage of providing guidance to policy makers and other stakeholders.

In the following, the economics of agrobiotechnology will be discussed, with special emphasis on the expected impact of agrobiotechnology on different levels of the research-development-application continuum. First, important economic characteristics of agrobiotechnology are presented. This is followed by a discussion of different methodologies to compare expected costs and benefits. Specific attention will be paid to a methodological approach that takes irreversibility and uncertainty into account. Section 4 discusses some empirical studies, while Section 5 presents the main conclusions and an outlook on future trends and research priorities.

2. Important Economic Aspects of Agrobiotechnology

From an economic point of view, the two most important aspects of agrobiotechnology that need to be considered relate to issues of efficiency and equity. Efficiency looks at the impact of agrobiotechnology on resource allocation and productivity within the economy, while the question of equity attempts to analyze how the benefits and costs of these new technologies will be distributed among different stakeholders. The three main stakeholder groups who are affected by or have an interest in agrobiotechnology are:

- the providers of the technology, namely universities, other public research institutions and private companies;
- the farmers as the main users of the technology; and
- the consumers as those who are confronted with the final products (figure1).

The questions regarding efficiency and equity can therefore be discussed at the level of research and development, at the production (= agricultural sector) level, and at the consumption level. In addition, national governments and international organizations as the regulatory bodies that have the power to influence the distribution of cost and benefits of the new technology also have to be considered. Furthermore, since agrobiotechnology will not only have an impact on western agriculture and society, but also on those of developing countries, who expect large benefits from its application, the conditions under which those benefits will materialize for the benefit of developing countries are of particular interest.

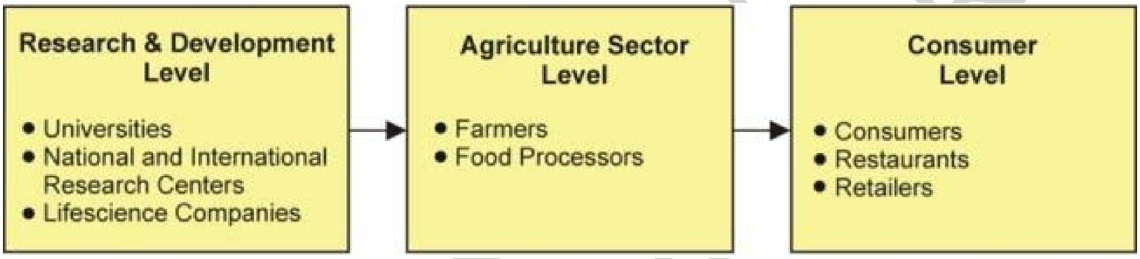

Figure 1: The main stakeholder groups in the agrobiotechnology chain

2.1 Research and Development Level

The basic foundations of agrobiotechnology have been developed by public research institutions in developed countries. However, the introduction of patents and other Intellectual Property Rights (IPRs) for biotechnology inventions provided an incentive for private companies to invest in the technology, so that now private investments in agrobiotechnology research exceed those of the public sector manyfold. A patent puts its owner in the position of a temporary monopolist for the supply of a specific product. For as long as the patent is valid, the owner can exploit monopolistic profits (see also - *Inventions, patents and morality*). This situation can be justified by the high initial investments needed to generate an invention. Without intellectual property protection, the private sector would have no incentive to invest in research and less technical change would be generated.

The nature of agrobiotechnology, which relies on seeds as the carriers of the invention, has resulted in several mergers and acquisition (M&As) between biotechnology and seed companies. Biotech companies, which were able to incorporate new traits into existing germplasm, did not have the seed distribution system necessary to capture the gains from their new developments. In order to bring their products to the market, biotech companies could either enter into contracts with seed companies, or they could actively engage in this part of the development process through vertical integration, i.e. by buying into the seed distribution system through M&As with seed companies. The latter option became dominant, as specifically transaction costs could be reduced considerable through M&As. However, this situation of concentration has given rise to concerns among many critics of agrobiotechnology as they see the market power of multi-national biotech-cum-seed companies as becoming overly strong.

The growing involvement of private companies in agrobiotechnology research has given rise to many new forms of public-private partnerships. These partnerships have changed the research sector in the US, especially with respect to the land-grant universities. The role of public research is put into question as the share of privately financed research projects at public research institutions increases. On the one hand, public research institutions need partnerships with private companies to access the protected germplasm, molecular tools and processes of these companies, but also to commercialize their own research findings for the public benefit. On the other hand, the independence of public research and the character of public research as a public good is threatened by too much private sector involvement. Most notable in this respect is the contract between the U.C. Berkeley's College of Natural Resources and the life-science company Novartis, in which Novartis made an initial commitment of US$ 25 Mio. to fund research and obtained the right to negotiate licenses on the research results. The structure of such emerging public/private partnerships is also important for the development of agrobiotechnology for developing countries where private investment in agricultural research remains negligible. Many life-science companies hold property rights on genetic material of world food crops like rice or corn. This limits the research possibilities of public institutions, including the international agriculture research centers. Partnerships between the private sector and national and international research centers have been discussed to improve the research potential of the centers.

2.2 Agriculture Sector Level

There are three important aspects that have to be considered when analyzing investments in agrobiotechnology at the farm level. First, investments in agrobiotechnology are done under temporal uncertainty, second they are to a certain degree irreversible, and third they can be postponed into the future. While the first aspect concerns mostly the farmers' decision to use a transgenic variety, the latter two aspects become important at the level of society in the decision on whether or not to release a transgenic variety for public use.

Temporal uncertainty exists since future prices, yields, and costs of the new products are unknown. The price of genetically engineered crops may increase or decrease compared to "conventional" varieties for a number of reasons such as consumer reactions or government regulations. For example, the relative price of GM-varieties may decrease if consumers are willing to pay a premium for GMO-free products. On the other hand, the relative price may also increase if an increasing number of consumers believe that GMO products have a higher value than non-GMO products, for example because of higher nutritional value. On the production side, the relative variable costs may increase or decrease depending on prices for the different inputs needed as well as differences in production technology. For example, the culture of herbicide-tolerant plants (see also - *Crop protection through pest resistance genes*) may reduce the number of herbicide applications and hence reduce the variable costs for oil.

Furthermore, the relative changes in yield are unknown. All three, product prices, variable costs, and yields, contribute to the farmers' uncertainty about the relative changes in future gross margins. In addition, regulations regarding the development, release and use of agrobiotechnology products may change over time. As additional information on the environmental impact of GMOs becomes available, regulating agencies will start to implement guidelines for their use, which may add additional costs to the producer, processor or developer.

Irreversibility exists as a release of genetically modified organisms may have a negative impact on the environment (see also - *Potential effects on biodiversity*). There are long-term risks related to the widespread use of transgenic crops. For example, gene flow in plants can enable domesticated plants to become pernicious weeds, or it can enhance the fitness of wild plants, which might turn out to be serious weeds, thus shifting the ecological balance in a natural plant community (see also - *Biotechnology and agro-biodiversity*). New viruses could develop from virus-containing transgenic crops. Plant-produced insecticides might have harmful effects on unintended targets. While some of these scenarios are highly unlikely, little is known about the overall impact that transgenic crops can have on biodiversity, ecosystem balance and the environment in long run.

The decision to release transgenic crops into the environment can be postponed. Government bodies who decide about releasing GMOs have the option to delay the decision and to ask the applicant to provide additional information to reduce the decision-related uncertainty.

All three, uncertainty, irreversibility and the option to delay the decision have an impact on the decision rule for releasing GMOs into the environment, as will be shown below.

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Bibliography

AgBioForum (1999): Volume 2(1-4).<http://www.agbioforum.org/> [Online journal addressing the economics of agrobiotechnology with special issues on impact for public and private sector research, Vol.2(1), impacts at the farm level, Vol.2(2), and economics of biotechnology in developing countries Vol.2(3/4)].

Alston, J.M., Norton G.W., Pardey, P.G. (1998): *Science under Scarcity*. CAB International: New York. [Illustrates the economic approach for the evaluation of agriculture research].

Demont, M., Wesseler, J., Tollens, E. (2004): Biodiversity versus transgenic sugar beets – the one Euro question. *European Review of Agricultural Economics* 31(1):1-18. [Assesses the benefits and costs of transgenic sugar beets in the EU considering irreversibility and temporal uncertainty].

Kendall H.W., Beachy R., Eisner T., Gould F., Herdt R., Raven P.H., Schell J.S., Swaminathan M.S. (1997): *Bioengineering of Crops*. Environmental and Socially Sustainable Development Studies and Monograph Series 23. The World Bank: Washington DC. [Lists and discusses the risk related to the release transgenic crops into the environment].

Lele U., Lesser W., Horstkotte-Wesseler G. (eds.) (1999*): Intellectual Property Rights in Agriculture*. The World Bank: Washington, DC. [Provides an overview about issues on IPRs from different country perspectives].

Raney, T. (ed.) (2004): *The State of Food and Agriculture 2003 -2004. Agricultural Biotechnology. Meeting the Needs of the Poor?* Food and Agriculture Organization of the United Nations [Presents contributions of leading experts on economic, environmental, ethical, health, regulatory, and social issues related to biotechnology for developing countries].

Scatasta, S., Wesseler J., Demont, M. (2006): *A Critical Assessment of Methods for Analysis of Social Welfare Impacts of Genetically Modified Crops: a Literature Survey*. Working Paper Mansholt Graduate School MWP-27, Wageningen University. [Review of ex-ante and ex-post assessments of agriculture biotechnologies].

Wesseler, Justus (ed.) (2005): *Environmental Costs and Benefits of Transgenic Crops.* Dordrecht, NL: Springer Press. [Provides an overview about the important issues for assessing benefits and costs of transgenic crops from the natural as well as social science point of view].

Wesseler J. (1997): *Die Ökonomik der Einführung von Obstkulturen in der Cordillera Central von Nordluzon, Philippinen*. Forschungsberichte zur Ökonomie im Gartenbau, Band 84. Shaker-Verlag, Aachen. [Demonstrates the use of a partial equilibrium model using Monte-Carlo simulation to assess the ex-ante cost and benefits of a new technology and provides an approach to elicit the individual rate of time preference.]

Biographical Sketch

J. Wesseler has received a PhD from the University of Göttingen, Germany in Agricultural and Environmental Resource Economics in 1996. His main field of research is decision making under uncertainty and irreversibility using the real option approach applied to impact assessment and cost-benefit analysis of new agriculture technologies, natural resource management systems and rural development projects. Since 1998 he has been working as a consultant providing expertise to the Food and Agriculture Organization of the United Nations (FAO), the German Association for Technical Cooperation (GTZ), and the German Bank for Reconstruction (KfW). His international assignments include work in countries like Azerbaidschan, Brazil, India, Kenya, Malawi, Paraguay, and the Philippines.