Katholieke Universiteit Leuven
Faculty of Agricultural and Applied Biological Sciences

Working Paper
1999 / 53

THE ECONOMICS OF AGRICULTURAL BIOTECHNOLOGY: HISTORICAL AND ANALYTICAL FRAMEWORK

Matty DEMONT and Eric TOLLENS

October 1999

EUWAB-Project (European Union Welfare effects of Agricultural Biotechnology), Project VIB/TA-OP/98-07**:** “Micro- and Macro-economic Analysis of the Economic Benefits and Costs of Biotechnology Applications in EU Agriculture - Calculation of the Effects on Producers, Consumers and Governments and Development of a Simulation Model”

Financial support of the VIB – Flanders Interuniversitary Institute for Biotechnology is gratefully acknowledged.

Department of Agricultural and Environmental Economics
K.U.Leuven
Willem de Croylaan 42, B-3001 Leuven – Belgium
Tel. +32-16-321614, Fax +32-16-321996

Demont, M., and E. Tollens. "The Economics of Agricultural Biotechnology: Historical and Analytical Framework." Working Paper, n° 53, Department of Agricultural and Environmental Economics, Katholieke Universiteit Leuven, 1999.

Matty Demont,
Flanders Interuniversitary Institute for Biotechnology (VIB),
Departement of Agricultural and Environmental Economics, K.U.Leuven,
de Croylaan 42, B-3001 Leuven (Heverlee), Belgium
Tel.: +32 16 32 23 98, Fax: +32 16 32 19 96,
Email: matty.demont@agr.kuleuven.ac.be

Prof. Eric Tollens,
Departement of Agricultural and Environmental Economics, K.U.Leuven,
de Croylaan 42, B-3001 Leuven (Heverlee), Belgium
Tel.: +32 16 32 16 16, Fax: +32 16 32 19 96,
Email: eric.tollens@agr.kuleuven.ac.be

The EUWAB-project (European Union Welfare Effects of Agricultural Biotechnology)

Since 1995, genetically modified organisms have been introduced commercially into US agriculture. These innovations are developed and commercialised by a handful of vertically coordinated “life science” firms who have fundamentally altered the structure of the seed industry. Enforcement of intellectual property rights for biological innovations has been the major incentive for a concentration tendency in the upstream sector. Due to their monopoly power, these firms are capable of charging a “monopoly rent”, extracting a part of the total social welfare. In the US, the first *ex post* welfare studies reveal that farmers and input suppliers are receiving the largest part of the benefits. However, up to now no parallel *ex ante* study has been published for the European Union. Hence, the EUWAB-project (European Union Welfare effects of Agricultural Biotechnology) aims at calculating the total benefits of selected AgBiotech innovations in the EU and their distribution among member countries, producers, processors, consumers, input suppliers and government. This project (VIB/TA-OP/98-07) is financed by the VIB - Flanders Interuniversitary Institute for Biotechnology, in the framework of its Technology Assessment Programme. VIB is an autonomous biotech research institute, founded in 1995 by the Government of Flanders. It combines 9 university departments and 5 associated laboratories. More than 750 researchers and technicians are active within various areas of biotech research. VIB has three major objectives: to perform high quality research, to validate research results and technology and to stimulate a well-structured social dialogue on biotechnology. Address: VIB vzw, Rijvisschestraat 120, B-9052 Gent, Belgium, tel: +32 9 244 66 11, fax: +32 9 244 66 10, www.vib.be

Abstract

In this working paper we attempt to establish a general analytical framework for the calculation of the micro- and macroeconomic benefits and costs of biotechnology applications in EU agriculture. Since these innovative applications are typically protected by intellectual property rights, standard welfare analyses will overestimate total benefits generated by these innovations. On the other hand, this doesn't mean that innovators are extracting all of the benefits. A recent *ex-post* welfare analysis on US Bt-cotton shows that farmers have captured the largest share of benefits (Falck-Zepeda, Traxler and Nelson, 1999). Due to the importance of intellectual property rights and the consolidation of the agricultural input industry, the framework presented by Moschini and Lapan (1997) seems to be the most adequate model as it takes into account these elements.

Introduction

Even the optimists among biotechnology proponents have been impressed by the extremely fast farm-level adoption of bioengineered crops in the United States (US). In 1999, just four years from commercial introduction, an estimated 40 % of the total US corn, soybean and cotton acreage were planted with herbicide- and insect-resistant bioengineered crops (Kalaitzandonakes, 1999). According to Fetrow (1999), since its approval in the US in 1994, rBST (recombinant bovine somatotropin) has been rapidly adopted by the dairy industry. Today, of the nearly 9 million dairy cows in the US approximately 30 % receive the product during a lactation.

However, while the agricultural sector is still revelling in the success of these biotechnological innovations based on a *single input trait*, executives and stockholders believe that a real agricultural revolution is still to be expected with the introduction of *stacked input traits*, *quality traits* and *combinations* of these traits (Coaldrake and Thomas, 1999).

These innovations are being developed and commercialised by a handful of vertically coordinated “life science” firms who have fundamentally altered the structure of the seed industry. Using mergers, acquisitions and licensing agreements, they ally their financial, scientific and organisational strengths with the genetic resources of traditional seed companies.

Enforcement of intellectual property rights (IPR) for biological innovations have been the major incentives for this concentration tendency in the upstream sector. On the one hand, Schumpeter (1942) suggests that this monopolisation may increase long run or dynamic, social welfare trough an increased rate of investment in research and development (R&D). On the other hand, due to their monopoly power, these firms are capable to charge a monopoly rent, extracting a part of total static social welfare.

Growing concern is being expressed about the idea of an input industry extracting all of the benefits generated by these innovations. In the US, the extremely high adoption rates of the first generation of bioengineered crops reflect that farmers are clearly receiving some benefits. Can this picture be extrapolated to the European Union (EU)? Which economic framework is appropriate to answer this question *ex-ante*? Which economic actors have to be taken into account and how can the research field be outlined? These are the central questions of this inception report.

Agricultural Biotechnology

Agricultural Biotechnology in the Literature

According to Riley and Hoffman (1999), biotechnology can be defined as *the use of biological organisms or processes in any technological application. Genetic engineering can be thought of as a subset of biotechnology, describing a set of techniques for altering the properties of biological organisms. Using genetic engineering techniques, individual genes can be transferred between organisms, or genes in an organism can be modified to create plants, animals, or microbes with improved traits for biotechnological applications*. Hence, in this and the following working papers the terms “biotech” or “biotechnology”, “genetically engineered” and “genetically modified” are used interchangeably.

Persley (1990) presents the major applications of agricultural biotechnology as a continuum of related technologies, requiring an increasing level of scientific knowledge, technical sophistication, financial support and time for success. This “gradient” of biotechnologies is illustrated in Figure 1. Primarily, this presentation emphasises the progressive and continuous nature of the biotechnologies. The discoveries made in the simpler technologies (downwards) led to those made in the more complex ones, and usually the simpler technologies are required for the success of the more complex ones. Secondly, the gradient nature of the biotechnologies also reflects the increasing need of basic scientific knowledge.

Our research will be concentrated on the last four agricultural biotechnology applications and mainly on genetic engineering of plants as agricultural innovation. In the literature, two waves are distinguished in this innovation (Kalaitzandonakes, 1999; Coaldrake and Thomas, 1999; Hillyer, 1999; Riley and Hoffman, 1999):

1. The *first wave* of biotechnology innovations is based on *input traits* or *agronomic traits*. Insertion of a gene in the plant genome protects the plant against pests or herbicides. Early commercial products include *Bacillus thuringiensis* (Bt) corn. These genetically altered hybrids contain a naturally occurring soil bacterium, Bt, that kills European corn borers. *Bacillus thuringiensis* cotton protects the crop against tobacco budworm and bollworm. To fight weeds, farmers have several genetically engineered options to choose from. Roundup Ready ® (glyphosate-tolerant) soybeans and corn, and LibertyLink ® (glufosinate ammonium) corn are some examples. These crops are immune to the broad spectrum, but non-selective herbicides, such as Roundup ®, Touchdown ® and Liberty ®. When applied, the herbicide kills the weeds without harming the crop. In the case of cotton, farmers

can turn to BXN ® (Bromoxynil) or Roundup Ready ® herbicide-tolerant varieties. More herbicide-resistant crops are on the way.

2. The *second wave* of biotechnology is based on *output traits* or *quality traits*. Unlike input traits that are designed to protect and enhance yield, output traits promise to enhance the value of the crops from the farmer to the consumer. For growing tailored traits, farmers can earn premiums on each kg. Early efforts in valued-added crops have focused on enhancing the value of animal feed since livestock are the dominant users of feedgrains. This has led to the development of high-oil corn and hybrids with increased levels of amino acids and starch, to name a few. Other traits include low phytate corn, also known as high available phosphorus corn, that increases the digestibility of the phytate nutrient by swine and poultry. As a result, less phosphorus is excreted in the manure, making it more environmentally friendly. For soybeans, many of the tailored traits are being developed to produce healthier oils and soy foods. The most common speciality soybeans are high oleic, high sucrose, low saturate, low linolenic and low null (produces a less beany taste). Work is also progressing to turn plants into factories, using bio-engineered crops for renewable energy sources and industrial uses. Genetic engineering may also help tailor plants into nutraceuticals, the blending of a regular food product with a health-enhancing attribute, like calcium-enriched orange juice (Hillyer, 1999). Finally, some see biotechnology as a way to use plants to produce vaccines and other important medicines, so-called "pharming" (Zilberman, Yarkin and Heiman, 1999).

However, the picture can be considerably complicated when we consider stacking[1] options. While stacked varieties combining agronomic traits will be commercialised in the near future, it is highly likely that quality traits will be combined with other quality traits and with agronomic traits (Coaldrake and Thomas, 1999).

Zilberman, Yarkin and Heiman (1999) use a product-based economic classification of agricultural biotechnology (agbiotech) applications. They consider agbiotech as an extension of traditional breeding techniques that increases precision (allowing for selection of individual traits) and versatility (permitting genes to be obtained from virtually any organism). They distinguish four types of products, each with different technical and economic implications:

1. *Supply enhancing products* (first wave);
2. *Pest control products* (first wave);
3. *Quality modifying biotechnology innovations* (second wave);
4. *New products*, e.g. "pharming" (second wave).

Thus, unless labelling techniques are applied to distinguish GMO and non-GMO products, the products issued from first wave agbiotech innovations are identical goods facing the same demand function. On the other hand, second wave innovations generate products with new characteristics easily recognised and distinguished by customers. In that case, the product faces a specific demand function with specific characteristics. The application of labelling techniques results in a segmentation of the product market in two groups, GMO and non-GMO, each group characterised by a specific demand function.

Agricultural Biotechnology as a Technical Change

To study the socio-economic impact of agbiotech innovations, we make abstraction of the intrinsic aspects of the technology itself by considering it as a technical change, i.e. a change in the production function. The economic theory of technical change has been subject to numerous corrections, adaptations and refinements. In the late fifties and early sixties, Griliches (1957; 1958; 1963; 1964) published a series of articles presenting a method of measuring the social returns of research costs of hybrid corn and related innovations (Griliches, 1957). Until today, researchers studying the economics of technical change refer often to his economic framework.

Most studies have relied on measuring changes in the economic surplus (consumer and producer surplus) evaluated in the agricultural product market. The basic idea is that improved production techniques allow farmers to supply a larger amount of output for any given price level. Let Q be total pre-innovation physical agricultural output produced by a farmer with the traditional technology, characterised by the production function $Q = f(X_1, X_2, ..., X_n)$ with $X_1, X_2, ..., X_n$ total physical input of production factors $i = 1, 2, ..., n$. When the farmer adopts the new technology, reflected by the production function $Q = g(X_1, X_2, ..., X_n)$, three scenarios are possible (Binswanger, 1974; Blackorby, Lovell and Thursby, 1976):

1. Hicks neutral (HN) technical change: output $Q(X_1, X_2, ..., X_n)$ increases without affecting the shares of physical input levels $X_1, X_2, ..., X_n$ (Hicks, 1932);
2. Input-saving technical change: output $Q(X_1, X_2, ..., X_n)$ increases while decreasing the share of physical input level of at least one factor X_I;
3. Input-using technical change: output $Q(X_1, X_2, ..., X_n)$ increases while increasing the share of physical input level of at least one factor X_I.

This increase of physical agricultural output results in a shift of the supply curve affecting producers' and consumers' welfare. In most cases the innovation affects differently the inframarginal, "low average cost" producers, located towards the "bottom end", i.e. near the vertical axis, of the supply curve, and the marginal, "high average cost" producers located at the "top end" of the supply curve. This phenomenon gives rise to three types of supply shifts (Lindner and Jarrett, 1978):

1. Parallel supply shift: the cost structures for all producers are reduced with the same amount;
2. Divergent supply shift: the cost structures for all producers are proportionately reduced;
3. Convergent supply shift: the cost structures for all producers are disproportionately reduced as social elite groups, represented by inframarginal producers, control the innovation.

These six specific assumptions have changed from study to study, summarised by Norton and Davis (1981), Huffman and Evenson (1993) and Alston, Norton and Pardey (1995).

Agbiotech in a Historical Context of Agricultural Innovations

In this section, we place agbiotech in a historical framework, based on the research of Mazoyer and Roudart (1997), to compare its intrinsic features with the major agricultural innovations which occurred in the European temperate regions.

At the end of the Middle Ages, Europe had already known three agricultural revolutions: the Neolithic, Antic and Medieval revolutions. These revolutions have engendered three major farming systems: shifting cultivation systems based on temporary "slash and burn" cultivation, fallow systems based on light ox-drawn ploughs and fallow systems based on heavy ox-drawn ploughs. From the sixteenth to the nineteenth century, most of the European regions were subjected to a new agricultural revolution, the *first agricultural revolution of Modern Times*.

This revolution led to the apparition of new farming systems: fallow has been replaced by artificial pastureland with grasses like ray-grass or fodder leguminosae. In the new rotation systems, fodder grasses alternate continuously with food crops facilitating the development of cattle breeding which, in turn, provides manure and mechanical energy (animal traction). Yields increase and the improvement of animal feeding and plant fertilisation stimulates animal and plant selection. In short, the first agricultural revolution of Modern Times led to an important increase of agricultural output obtained by only a few investments and little supplemental labour, i.e. an increase in the labour productivity, represented by the marginal product of labour L: $MP_L = dQ/dL$.

The first agricultural revolution of Modern Times can be seen as an *endogenous organisational innovation* characterised by an important *Hicks neutral* component of technical change. According to Lindner and Jarrett (1978), organisational innovations are mostly scale dependent and result in a *convergent shift of the supply curve*. If low cost producers correspond to skilled managers, then they are located at the bottom end of the supply function. To the extent that the benefits of organisational innovations are positively correlated with managerial ability, the reduction in average costs is greater for such farmers relative to their "high cost" counterparts at the top end of the supply curve.

These productivity gains have brought to an end the crisis of the fallow systems that broke out in the fourteenth century and extended up to the eighteenth century. For the first time in history, a new agriculture appears, capable to produce a commercial surplus. By providing the growing industry with raw materials, labour and food, this has played a central role in the *first industrial revolution*. In exchange, this productive agriculture, consuming iron, tools, etc., has become an important outlet for industrial products.

At the end of the nineteenth and in the beginning of the twentieth century, industry produces new means of transport and new agricultural equipment bringing agriculture to its first world crisis of overproduction in the years 1890. The *second agricultural revolution* extends this first phase of mechanisation up to the twentieth century, hinging on the development of new agricultural production means issued from the *second industrial revolution*:

- motorization (explosion motors, …);
- big mechanisation (complex and powerful machines, …);
- "chemistralisation[2]" (fertilisers, drugs, phyto-sanitary products, …);
- "biologisation" (selection and breeding, *in vitro* cultivation, biotechnology, …).

Kershen (1999) proposes an analogous terminology distinguishing three eras: the era of physics (eighteenth and nineteenth centuries), chemistry (twentieth century) and biology (twenty-first century). Note the strong complementarity that exists between these scientific innovations. In order to obtain important yield increases, only adding fertilisers can not do this; again selected plant varieties capable to absorb and make a profit out of the added inputs, should be available. Besides the adaptation of the plants to the increased use of fertilisers, plant variety selection aims also at the adaptation of the plants to the use of new mechanical equipment and the enforcement of resistance against diseases and pests.

Today, in the industrialised countries only 5 % of the total active population are sufficient to nourish, better than ever, the population. We assist at an important substitution of labour by capital, coupled with an enormous increase of labour productivity. Hence, the second agricultural revolution, characterised by strong *labour-saving*, *capital-using* and *land-using* components, has been even faster than the precedent agricultural revolutions. This revolution is also unequal: among the mass of farms that existed in the beginning of the century, only a small minority has managed to cross all phases. Certainly, big capitalistic farms using hired labour and capable to acquire the necessary capital have been in a privileged position, while the majority of the exploitations have encountered a crisis and have disappeared. As suggested by Lindner and Jarrett (1978), these innovations are likely associated to a *convergent shift of the supply curve*. Nevertheless, notwithstanding this evolution, the familyl farm remains the predominant production unit of the industrialised countries.

The phases of motorization and mechanisation reveal themselves by surface increases of cultivated land or increases in herd size per unit labour leading to important labour productivity increases. Conversely, agricultural innovations resulting from scientific progress in chemistry and biology engender increases of yields per unit land or per animal affecting on-farm added value. The latter two phases of the second agricultural revolution are characterised by *input-using* (fertilisers, more effective pesticides, …), *input-saving* (pesticides that substitute for other inputs, …) as well as *Hicks-neutral* components (more productive seed varieties). Moreover, these innovations are likely to result in a *divergent shift of the supply curve* since they reduce proportionately the cost structures for all producers (Griliches, 1957; Lindner and Jarrett, 1978).

Since the farms don't have to produce their own inputs and equipment anymore, they abandon the former polyproduction systems for more specialised production systems, oriented towards a few cash crops. The choice of these crops depends on the expected profits taken into account the biophysical and economical conditions of the region and the specific production conditions of the farm. An extensive multi-regional agrarian system has been created, composed of specialised and complementary regional sub-systems (pastureland regions, fruit regions, viticulture regions, meat or milk cattle breeding, …), providing one national or international market. This system is inserted in an ensemble of upstream industries (mechanical, chemical, biological and biotechnological industries) providing inputs and downstream industries (storage, transformation and commercialisation).

The new system is characterised by a strong *horizontal labour division* between the regional sub-systems and a strong *vertical labour division* between the upstream, the agricultural and the downstream sector. Due to this strong labour division, development of new production factors (machines, fertilisers, pesticides, vaccines, animal feeding, genetically selected varieties and races, …) flows gradually from the farm to the surrounding sectors. These functions have been absorbed by a new group of intellectual workers in public or private centres of research, education and extension.

What's the place of agricultural biotechnology in this historical framework? Some scientists believe that the unique features of these innovations will reshape agriculture as profoundly as any other past paradigm change (Zilberman, Yarkin and Heiman, 1999). Do we have to do with a *third agricultural revolution*? Remember the two waves we distinguished in section 1.1. The specific features of the first wave are entirely coherent within the paradigm of the second agricultural revolution. The biologic innovations tend to substitute or complete the chemical innovations. Through multimarket exploitation, chemical companies develop biotechnology that increases dependence on chemicals, whereas nonchemical companies tend toward development of biotechnology that substitutes for chemicals (Just and Hueth, 1993). Hence, first wave agbiotech can be seen as a continuation of the second agricultural revolution model.

By comparing first with second wave agbiotech, a *new paradigm* emerges. Some executives believe that these innovations will improve profitability on the farm (Coaldrake and Thomas, 1999). Improved quality traits and total new products ("pharming") with a very high added value and oriented to specific niche markets could profoundly reshape the role of agriculture as a commercial sector. Whether these elements would bring agriculture in a *third agricultural revolution* is not clear yet in this changing environment.

Intrinsic Features of Agbiotech as an Agricultural Innovation

Despite the fact that first wave agbiotech is in line with the general philosophy of the second agricultural revolution, this innovation brings along some completely new features. According to Lesser (1999), the 1980 date is pivotal in the US agricultural input industry as it marks some strengthening amendments to the US Plant Variety Protection Act. At that time, a number of observers identified a direct causal relationship between the strengthening of intellectual property rights (IPRs), merger activity of the US seed industry and investments by private firms in plant biotechnology research (Moschini and Lapan, 1997; Lesser, 1999; Brennan, Pray and Courtmanche, 1999).

One of the key differences in agbiotech from previous agricultural innovations is that the new innovations have *intellectual property rights* that produce private value that is more easily captured by the inventors of that intellectual property than was the case in the past. Previously, the natural ability of crops and animals to reproduce meant that it was not possible to capture the intellectual property value of agricultural products. Therefore, to prevent under-investment in new agricultural technology, most genetic improvements were subsidised by the state or developed directly by state-funded research establishments. This has changed with the advent of modern biotechnology. The proportion of the value of an agricultural good represented by intellectual property has risen accordingly (Kerr, Yampoin and Hobbs, 1999; Foltz, Barham and Kim, 1999). Hence, once again in recent history an ancient function, namely genetic selection, flows from the farm to the upstream industry sector.

Privatisation of the Commons?

The broad literature that exists on the changing structure of the seed industry reflects some increasing international concerns. Firstly, some authors are concerned about the so-called "privatisation of the commons". The traditional research paradigm represents discoveries flowing linearly from basic science conducted in public institutions to applied research and commercialisation undertaken largely by private industry. Recent US legislation aimed to promote economic growth through supporting research acknowledges the "blurring of lines" between public and private research activities (Rausser, 1999). Moreover, the increased collaboration between private firms and US State Agricultural Experiment Stations (SAES) raises fears that the independence, objectivity and credibility of SAES and their scientists may be compromised. Likewise, there is concern that public funds provided to these institutions will be expended for private gain (Holt and Bullock, 1999). There is evidence that public-private ventures can foster socially beneficial research, but a strong public research sector will remain important, as it can allay concerns about industry's role in R&D (Klotz-Ingram and Day-Rubenstein, 1999). Moreover, the potential for market failure resulting from under-investment in research is another justification for public agricultural research (Sonka and Pueppke, 1999).

Another wide-spread concern is the fear that the ability of companies to gain IPRs over what were formerly freely available community resources (seeds, plants and even micro-organisms) will have devastating effects on both human communities and the protection of biodiversity (Dawkins, Thom and Carr, 1995). Conversely, innovation that took place in communities over centuries, or even innovation in plant varieties that takes place in the present in a communal fashion, is not eligible for protection (Lehman, 1994). The international concern has come to a climax with the introduction of so-called *terminator genes* imposing a "natural" barrier to the farmer's ancient right to harvest and reuse a part of his seeds.

A third concern is related to the relationship between the industrialised and the developing countries. Patent protection often covers crops that are particularly important in developing countries such as cotton, sorghum, cassava, millet, banana and rye. This "genetic colonialism" will ensure that the North can control and profit from their use and secure import monopolies by preventing local production (Meister and Mayer, 1995).

A fourth well-known concern, often referred to by opponents of biotechnology, is the potential for too much monopoly power due to the increasing consolidation and concentration of the agricultural input market (Hayenga, 1999). Brennan's (1999) analysis of the impacts of this phenomenon reveals that new firm entry in the innovation market is starting to show evidence of decline. Research output by firms not in the top four also appears to be falling, and gains to efficiency appear to be negatively related to firm size. Investments and research output by the larger firms both appear to be increasing. Specific concern has been expressed about the firm Monsanto as it has dominated US and world markets since the early stages of the plant biotechnology industry. In the US, almost 90 % of the acreage planted with genetically engineered seed are using Monsanto Products (James, 1998).

Some opponents claim that we don't need biotechnology as only multinationals benefit. On the other hand, Schumpeter (1942) suggests that monopolisation may increase long run or dynamic, social welfare trough an increased rate of investment in research and development (R&D). We've put together the two extreme positions in the current biotechnology "multinational debate". Is it really the case that multinationals are extracting all of the benefits generated by their products, or are there other agents who benefit too?

General Analytical Framework

Intellectual Property Rights and the Welfare Effects of Agbiotech

In November 1997, Moschini & Lapan (ML) published the article "Intellectual Property Rights and the Welfare Effects of Agricultural R&D". In this article, ML argue that the conventional assumption of competitive pricing in the literature about the welfare effects of technological change cannot hold when new technologies are produced by private firms because such innovations are typically protected by IPRs. Conventional methods usually overestimate the welfare gains from agricultural innovations.

ML bring along some new elements in the analytical framework of welfare economics summarised by Huffman and Evenson (1993) and Alston, Norton and Pardey (1995). They complete the framework by including the possibility that the innovation is protected by IPRs, typically like in agbiotech innovations. Thus, the two interrelated factors that need to be considered in describing how the price for the new innovation is determined are (a) the previously existing *market structure* and (b) whether the innovation is *drastic* (leading to unconstrained monopoly price of the innovated input) or *nondrastic* (so that the monopolist's pricing decision is constrained by the threat of competition). So, the correct evaluation of the benefits from R&D aimed at agriculture needs to account for the relevant institutional and industry structure responsible for the actual development of technological innovations. Hence, the methodology presented in the ML-model will play a key role in our research as it is closely related to the central question of our research project.

General Analytical Framework

In Figure 2 we present the general analytical framework on which the simulation model and the case studies of the following working papers are based. In the middle the multistage biotechnology diffusion chain is presented. The arrows represent the influence of stages or agents on other stages or agents. In the following sections, we discuss the specific role of each stage in the agbiotech diffusion process.

Government represents the first stage in the agbiotech diffusion process as it can influence the structure of the national system of biotechnology innovation and the input industry. For this purpose, it has five policy instruments for influencing the penetration of agbiotech into the agbiotech diffusion chain:

1. Research expenditures;
2. Intellectual Property Rights (IPRs) legislation;
3. Regulatory approval;
4. Trade;
5. Labelling policies.

(1) By modifying the budget of the national (universities, institutes, …) and international agricultural research systems, government influences the share of public sector research, typically fundamental, basic research. As the latter forms the basis

for the more applied R&D, in a second phase government influences also applied R&D, typically private sector research. Using patent data Foltz, Barham and Kim (1999) show with an econometric model the importance of the US land grant university infrastructure, technology transfer offices and star scientists in the public sector production of agbiotech patents.

(2) Between the two extremes of (I) a patent system where IPRs are not respected and patent owners sell seeds directly to growers and (II) a patent system where IPRs are respected and patent rights are sold, there exists a continuum of IPR regimes associated with specific social costs and benefits. In this continuum, (III) a social optimum exists maximising the welfare of consumers and producers taking into account both production and research costs. Zilberman and Yarkin (1999) compare these three IPR regimes and show that the adoption rates will be highest under the social optimum and lowest where IPR is not respected.

When IPR is respected and the cost of modifying all varieties is low, adoption rates may be very high and introduction of biotechnology enables yield increases and maintains biodiversity. On the other hand, when IPR is not respected and only one biotechnology-modified variety is available, biodiversity may decline because the acreage of the modified variety may increase, and it may lead to elimination of some of the traditional varieties. Under the social optimum, if the industry is facing an elastic demand and output prices do not change, introduction of biotechnology may increase utilised land. Land expansion is less likely under IPR, because the seller of the seed will capture much of the rent increases through the seed rent. Land expansion is even less likely when only one variety is modified because of inability to protect

IPR. This is especially the case when the modified variety is the one that is suitable for higher quality land. When the demand for the final product in inelastic, output price and acreage may decline most with the high-yield variety .The smallest declines in both may be where only one variety is modified because IPR is not respected. In the case where output demand is inelastic, the social optimum will result in the largest gain for consumers and the largest reduction in pressure on the environment because it will require less land.

Less studied but very important are the actual and potential roles of compulsory licensing as an instrument of intellectual property policy. A compulsory licence is a property right provided to one or more agents by the licensing or patent authorities that allows the holder of the compulsory license to use, to infringe or to exploit the rights previously granted to someone else. Thus, a compulsory licence is a specific form of relaxation of, or exemption to, a right previously granted. A compulsory license may be granted subject to any number of terms, such as those that specify royalties or licence fees that must be paid to the holder of the original rights or terms that confer a reciprocal right or privilege on the original rights holder (Horbulyk, 1999). Horbulyk shows that in a sector like agbiotech industry where the R&D process is typically cumulative, provisions of compulsory licensing within a system of IPRs have a potential role in sustaining innovation and technological change in agriculture.

(3) The use of biotechnology in agriculture poses possible risks to human, animal, and plant health and life, and to the environment. These are grouped under the rubric of sanitary and phytosanitary (SPS) risks and regulations. They fall under the SPS

Agreement administered by the World Trade Organization (WTO). Risk analysis is the preferred international approach to managing SPS risks. It has been defined as a three-stage process, including risk assessment, risk management, and risk communication. Under the SPS Agreement, countries are encouraged in their regulatory programs to use international standards set by the International Office of Epizootics (OIE), Codex Alimentarius Commission (Codex), and International Plant Protection Convention (IPPC). Differences between countries in rates of and conditions on regulatory approval of agricultural biotechnologies result from different approaches to the factors included in risk analysis *and* the inclusion of different factors (Caswell, 1999). The influence of regulatory approval on the development of the agbiotech industry is well known in the EU. Due to its regulatory uncertainty, the European biotechnology industry has been quickly dominated by the US, independently of international differences in inherited resource endowments (Lavoie and Sheldon, 1999).

(4) However, if there is no SPS risk involved, regulations related to agricultural biotechnology, other than those dealing with intellectual property rights issues, fall under the Technical Barriers to Trade (TBT) Agreement (Caswell, 1999). Under the General Agreement on Tariffs and Trade (GATT) administered by the World Trade Organisation (WTO), regulations imposed by governments which inhibit the free flow of international commerce are considered non-tariff barriers to trade. One of the responsibilities which has been mandated to the WTO is determining when non-tariff barriers to trade are legitimate and when they are being used capriciously to protect domestic vested interests. A major international dispute is brewing over the issue of whether the regulatory regimes being put in place to govern GMOs of agricultural

significance are capricious barriers to trade. The current focal point of the dispute is the EU, but one suspects that many countries are watching the evolving situation closely to see what precedents arise (Perdikis, Kerr and Hobbs, 1999).

(5) Labelling policies are the fifth alternative of governments to regulate diffusion of agbiotech innovations in the agbiotech technology diffusion chain. The choice of labelling policy has an important impact on the initial direction and speed of development of markets for foods produced with the use of GMOs, if consumers care about this product attribute. Labelling policy is particularly important if it is linked to regulatory approval and market access. For example, a country or country-group may allow market access only if labelling is in place to protect the rights of consumers to know and to choose. In the longer run, labelling policy will be important to the extent that consumers view the use of biotechnology as an important attribute to select for or against. If they do not, then labelling policy is likely to atrophy. The regulatory options available to governments for labelling of GMOs at retail include (Caswell, 1999):

1. Allow no labelling regarding the use or nonuse of GMOs;
2. Require mandatory labelling of products that use GMOs;
3. Allow voluntary labelling of products that do or do not use GMOs;
4. Allow voluntary labelling of products that do not use GMOs, with an accompanying disclaimer noting the government's judgement about any differences (e.g. safety) between products that use and do not use GMOs.

The European Union has pursued the second strategy, while the US has chosen and stuck with the fourth policy since its labelling decision for rBST use. If these systems are too costly or do not meet with consumer acceptance, the market will tend to move toward not differentiating products produced with biotechnology or towards a ban on products produced with or containing GMOs, as it is the case in the EU.

Several other factors influence government policy decisions, like geography, history, religious and socio-cultural aspects (Zechendorf, 1998), political ideology and national and international institutional context (Bartholomew, 1997).

National System of Biotechnology Innovation and Input Industry

Bartholomew explores the relationship between national institutional context and the development of biotechnology in the United States, United Kingdom, Japan and Germany (Bartholomew, 1997). He distinguishes eight particular features of national institutional context, which affect the stocks and flows of scientific knowledge:

1. Tradition of scientific education;
2. Patterns of basic research funding;
3. Linkages with foreign research institutions;
4. Degree of commercial orientation of academia;
5. Labour mobility;
6. Venture capital system;
7. National technology policy;
8. Technological accumulation in related industrial sectors.

He also considers three R&D practices at the level of the firm:

1. Collaboration with research institutions;
2. Interfirm R&D cooperation;
3. Utilisation of foreign technology.

Bartholomew concludes that national patterns in biotechnology R&D are linked to the configuration of country-specific institutional features into a national system of biotechnology innovation which supports (or impedes) the accumulation and diffusion of knowledge between the scientific and industrial communities. Building on his comparative analysis, he argues that the particular characteristics of national systems of biotechnology innovation form the basis for complex interdependence within the global system.

According to Zilberman, Yarkin and Heiman (1999), three economic agents determine the outcomes of biotechnology discoveries in the national system of biotechnology innovation:

1. Universities (U in Figure 2) which conduct research that leads to important discoveries;
2. Small biotechnology firms (B) made up of researchers and supported by venture capitalists, which tend to concentrate on developing biotechnology products, often combining efforts and resources through alliances with pharmaceuticals, other biotechnology forms and academic researchers;
3. Large companies (M) which, in addition to internal R&D capabilities and alliances with biotechnology firms, have strong marketing networks in place and enough financial resources to bear the costs of product registration.

Barker (1999) completes the picture by adding a fourth agent: international agricultural research centres (IARC). IARCs were created with financial and technical support from the industrialised countries to help develop and disseminate new technology, largely because earlier efforts at direct technology transfer had failed. The broad literature that exists on the changing structure of the agbiotech industry shows how these four agents are interlaced. The structure, conduct and performance of this system are important for agriculture as it influences the technology price and thus the rate of agbiotech innovation adoption. This is the major contribution of the ML-model upon which our analyses will be based.

Agrarian System

Agbiotech innovations have an important impact on the farming system: production techniques, inputs and management are modified. These changes bring about important micro-economic benefits and costs at the farm level. Since commercial introduction of the first agbiotech innovations in 1995 in the US, the first *ex-post* studies calculating on-farm profits become available (Marra, Carlson and Hubbell, 1998; Culpepper and York, 1998; Roberts, Pendergrass and Hayes, 1998; Fernandez-Cornejo, Klotz-Ingram and Jans, 1999; Gianessi and Carpenter, 1999; McBride and Books, 1999; Butler, 1999; Fulton and Keyowski, 1999; Fetrow, 1999). For rBST only, although more than 1.500 articles have been written on the *ex-ante* adoption of this agbiotech innovation (Centner and Lathrop, 1996), very few *ex-post* studies have been carried out (Butler, 1999). Some authors report on studies carried out on rBST use in New York dairies (Lyson, Tauer and Welsh, 1995; Tauer and Knoblauch, 1997; Lesser, Bernard and Billah, 1999).

Other interesting farm-level features, less studied, are the impact of agbiotech innovations on specialisation and diversification patterns, farm size and the introduction of contract production. The introduction of rBST in the case of a milk quota, for instance, can generate a phenomenon of diversification, as a part of the acreage becomes superfluous due to the milk yield increase. This part can be used for another agricultural activity, like meat production.

At a higher level, that of the agrarian system, literature offers very little analyses of the impacts of agbiotech innovations. The analysis of regional specialisation, differentiated adoption rates among different classes of farmers (Fulton and Keyowski, 1999), inter-farm relations, vertical integration and sociological aspects could fulfil this need. Finally, represented by their farmer organisations, farmers can influence government policy decisions regarding agbiotech aspects (fat arrow in Figure 2).

Marketing System

First wave agbiotech innovations result essentially in a reduction of the production costs at the farm level. According to Freebairn, Davis and Edwards (1982), in a multistage production system, the reduction at one stage provides benefits to producers at all stages to consumers (Alston and Scobie, 1982). Hence, benefits, measured as changes in economic surplus flow from the farm sector, through the marketing sector, to the consumers.

The application of labelling techniques and the introduction of second wave agbiotech products complicate the picture as they generate market segmentation, new niche markets and cost reductions for the marketing sector (e.g. in the case of delayed ripening tomatoes).

Agricultural Market

Remember that we concluded the first part of our paper with the question "Is it really the case that multinationals are extracting all of the benefits generated by their products, or are there other agents who benefit too?" This will be the central question of the macro-economic welfare analysis and the simulation model which will be developed in the following working papers. We showed already the fitness of the ML-model to answer this question. While most of the economic agbiotech literature deals with the transforming agbiotech input industry and the calculation of the internal rate of investment of agbiotech research, very few studies analyse the welfare effects on different groups of the agricultural production chain. However, the first *ex-post* welfare analyses, carried out in the US, contain already convincing results (Falck-Zepeda, Traxler and Nelson, 1999). Falck-Zepeda, Traxler and Nelson show that even taken into account the IPR protection of Bt cotton, US farmers receive the largest single share of benefits, ranging from 42 % to 59 % of total surplus, while the combined share of the innovators, Monsanto and the seed firms, range from 26 % to 44 %. US consumers captured between 7 % and 9 % and the rest of the world obtained a net surplus ranging from 5 to 6 % of total surplus.

The main conclusion of their study is that even under monopoly conditions, the innovator is only able to extract a portion of the surplus that it creates. The monopolist must provide farmers with an adoption incentive by setting a price that makes the new input more profitable than existing options. This principle is well established in the adoption literature (Griliches, 1957).

In industrialised[1] countries, characterised by an inelastic demand and an elastic supply, typically consumers capture the largest share of the total benefits of an agricultural innovation. Cochrane (1958) depicted farmers as victims of technological change. In his analysis, only the earliest adopters could benefit from new technology, and their benefits were fleeting. Eventually, the price-depressing effects of increased output would offset the gains. Those who were slow to adopt or did not adopt would lose. He characterised the process as a "treadmill" that farmers must tread to survive but that involved unhappy consequences for agriculture. Hence, the analysis of Falck-Zepeda, Traxler and Nelson (1999) is a typical reflection of the adoption phase. In a second phase, consumer surplus is expected to increase as agricultural output prices drop due to the increasing technology adoption and agricultural production.

Consumers

While consumer acceptance and consumption risks are widespread subjects of analysis (Kalaitzandonakes, 1998; Caulder, 1998; Marshall, 1998; Loader and Henson, 1998; Phillips and Isaac, 1998; Chess, 1998; Miller, 1998; Zechendorf, 1998; Hoban, 1998; Isaac and Phillips, 1999; Zepeda, Douthitt and You, 1999; Kalaitzandonakes and Marks, 1999; Kershen, 1999; Perdikis, Kerr and Hobbs, 1999; Miller, 1998), few literature exists on the real or potential welfare effects, due to a change in consumer surplus (CS).

Consumer organisations lobbying for a moratorium (fat arrow in Figure 2) on the import of GMOs are very active in the EU. Under the General Agreement on Tariffs

---

[1] The opposite effect can be observed in developing countries. Farmers, facing an elastic demand and an inelastic supply, typically capture the largest share of the total benefits of an agricultural innovation.

and Trade (GATT) administered by the World Trade Organisation (WTO) no regulations are provided for consumer concerns as a legitimate reason for countries to apply trade measures. An analysis of Perdikis, Kerr and Hobbs (1999) shows the need for the inclusion of Trade Related Aspects of Consumer Concerns (TRACC).

Environment

Often-used arguments by biotechnology opponents are the potential long-term risks and biosafety aspects of releasing GMOs in the environment (Lehman, 1994; Van Dusen, 1999). Another wide-spread concern is the loss of biodiversity due to massive introduction of IPR protected GMOs (Dawkins, Thom and Carr, 1995; Dawkins, 1995).

While the authors of micro-economic impact studies, referred to in section 2.2.3, also calculate pesticide level reduction, only a few studies calculate overall risks, costs and benefits associated with the introduction of genetically engineered varieties in the environment (Wesseler, 1999; Sianesi, 1999; Hurley, Secchi and Hellmich, 1999). What is often neglected in the arguments of opponents is the fact that a decision to delay or reject a release of a GMO avoids those risks, but forgoes also the potential benefits of an immediate release. The benefits foregone have to be considered as a cost.

Even a decision which is based on the assumption that the risk cannot be estimated and therefore transgenic crops should not be released implicitly assumes that the expected risks are higher than the expected benefits (Wesseler, 1999). Via a real options approach, Wesseler brings about an important new element. He shows that traditional cost-benefit-analysis could result in socially non-optimal allocation of resources because the value of delaying a decision and waiting for additional information is neglected ("quasi-option value").

Delimitation of the Research Field

After this extensive review of the existing literature, we can define the research field of the EUWAB-project (European Union Welfare effects of Agricultural Biotechnology) in four dimensions:

1. Geographic dimension: the *European Union*;
2. Time dimension: *ex-ante* evaluation of the possible *future* economic impacts of biotechnology applications in agriculture;
3. Vertical dimension (the stages of the innovation diffusion chain that have to be taken into account): government, national system of biotechnology innovation and input industry insofar as they influence input price, farmers, agricultural market, consumers and the environment;
4. Horizontal dimension: determination of product-specific case studies. The simulation model has to be sufficiently general to take into account a number of agbiotech innovations. After the completion of this model, case studies will be selected in collaboration with research specialists and experts.

Conclusions

Agricultural biotechnology applications can be categorised in two waves: input traits and output traits. Second wave agricultural biotechnology applications are coherent within the paradigm of the second agricultural revolution of Modern Times.

Despite this fact, these innovations bring along some important new features. Since agricultural biotechnology applications are typically protected by intellectual property rights, standard welfare analyses will overestimate total benefits generated by these innovations. On the other hand, this doesn't mean that biotechnology companies are extracting all of the benefits. A recent *ex-post* welfare analysis on US Bt-cotton shows that farmers have captured the largest share of benefits (Falck-Zepeda, Traxler and Nelson, 1999). Due to the importance of intellectual property rights and the increasing concentration of the agricultural input industry, the framework presented by Moschini and Lapan (1997) seems to be the most adequate model as it takes into account these elements.

Furthermore, this model needs to be completed with analyses that take into account the potential benefits, risks and costs to the environment.

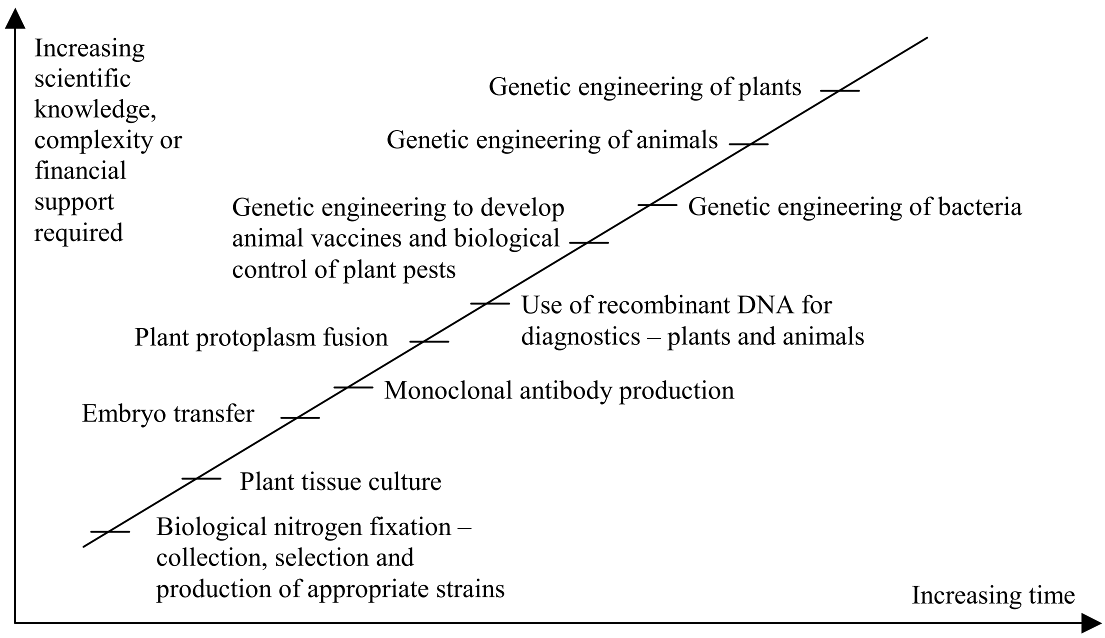

Figure 1: Gradient of biotechnologies (Persley, 1990)

GOVERNMENT

5 policy instruments:

1. Research expenditures
2. IPR legislation
3. Regulatory approval
4. Trade
5. Labelling policies

- National and international institutional context
- Politic ideology
- Geography, history

AGRARIAN SYSTEM (AS)

- Farming systems
- Microeconomic costs and benefits of agbiotech
- Specialisation
- Diversification
- Adoption rate and pattern
- Inter-farm relations
- Contract production

- Macroeconomic costs and benefits of agbiotech
- Producer Surplus (PS) welfare effects
- Consumer Surplus (CS) welfare effects
- Deadweight costs
- Government benefits and costs

CONSUMERS (C)

- Consumer acceptance
- Consumption risks

NATIONAL SYSTEM OF BIOTECHNOLOGY INNOVATION AND INPUT INDUSTRY

4 agents:

1. National Agricultural Research System (NARS)
2. International Agricultural Research Centre (IARC)
3. Small Biotechnology Firms (B)
4. Large Biotechnology Companies (M)

- Structure
- Conduct
- Performance

MARKETING SYSTEM (MS)

AGRICULTURAL MARKET

- Characteristics supply and demand
- International trade
- Market interventions
- Degree of competition
- Labelling policy

ENVIRONMENT

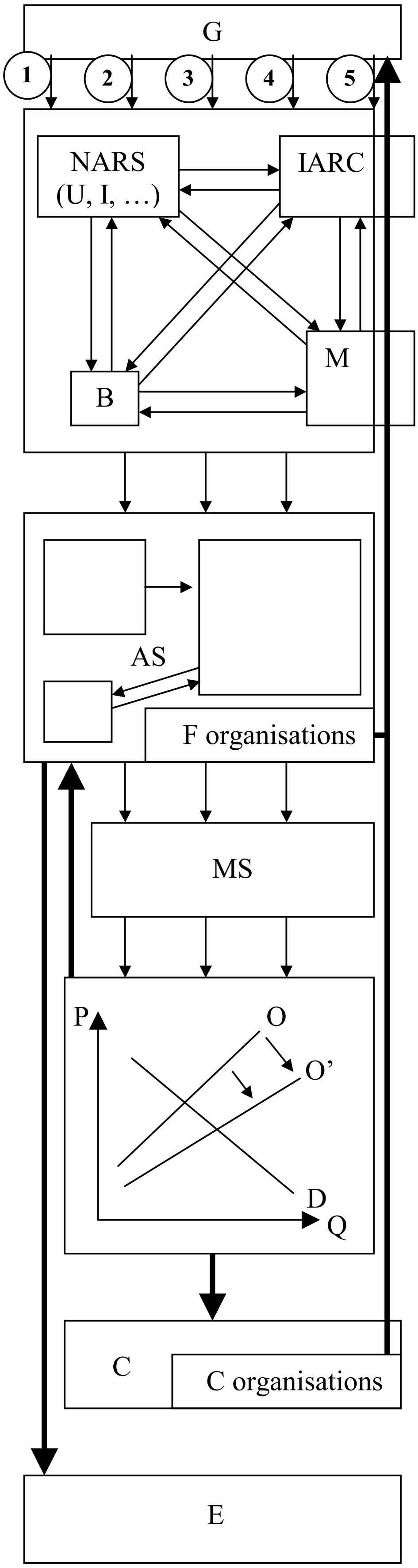

Figure 2: General Analytical Framework of the Agbiotech Diffusion Process

Reference List

Alston, J. M., Norton, G. W., and Pardey, P. G., *Science Under Scarcity: Principles and Practice of Agricultural Research Evaluation and Priority Setting,* Ithaca NY: Cornell University Press, 1995.

Alston, J. M. and G. M. Scobie, *Distribution of Research Gains in Multistage Production Systems: Comment,* American Journal of Agricultural Economics, 65(1982): p. 353-356.

Anonymous, *Agricultural Biotechnology Concepts and Definitions,* ERS Issues Center, Economic Research Service (ERS), United States Department of Agriculture (USDA), http://www.econ.ag.gov/whatsnew/issues/gmo/terms.htm, 20/7/1999, 2 p.

Barker, R., *Socio-economic Impact*, In: Persley, G. J., ed., Agricultural Biotechnology: Opportunities for International Development, Biotechnology in Agriculture, vol. 2, Wallingford, UK: C.A.B. International, 1999, p. 299-310.

Bartholomew, S., *National systems of biotechnology innovation: Complex interdependence in the global system,* Journal of International Business Studies, 28(1997): p. 241-266.

Binswanger, H. P., *The Measurement of Technical Change Biases with Many Factors of Production,* American Economic Review, 64(1974): p. 964-976.

Blackorby, C., C. A. K. Lovell, and M. C. Thursby, *Extended Hicks Neutral Technical Change: Notes and Memoranda,* Economic Journal, 86(1976): p. 845-852.

Brennan, M. F., Pray, C. E., and Courtmanche, A., *Impact of Industry Concentration on Innovation in the U.S. Plant Biotech Industry,* conference proceeding, Transitions in Agricultural Biotechnology: Economics of Strategy and Policy, Washington DC, June 24-25, 1999, 23 p.

Butler, L. J., *The Profitability Of rBST On U.S. Dairy Farms*, AgBioForum, vol. 2, http://www.agbioforum.missouri.edu, 1999, p. 111-117.

Caswell, J. A., *An Evaluation of Risk Analysis as Applied to Agricultural Biotechnology (with a Case Study of GMO Labeling),* conference proceeding, Transitions in Agricultural Biotechnology: Economics of Strategy and Policy, Washington DC, June 24-25, 1999, 19 p.

Caulder, J., *Agricultural Biotechnology and Public Perceptions*, AgBioForum, vol. 1, http://www.agbioforum.missouri.edu, 1998, p. 38-39.

Centner, T. J. and Lathrop, K. W., *Regulating the Scale of Products from Cows Treated with Recombinant Bovine Somatotropin*, Choices, vol. Fourth Quarter, 1996, p. 34-36.

Chess, C., *Fearing Fear: Communication About Agricultural Biotechnology*, AgBioForum, vol. 1, http://www.agbioforum.missouri.edu, 1998, p. 17-21.

Coaldrake, K. and Thomas, T., *Trait Enthusiasm Does Not Guarantee On-Farm Profits*, AgBioForum, vol. 2, http://www.agbioforum.missouri.edu, 1999, p. 118-125.

Cochrane, W. W., *Farm Prices: Myth and Reality,* Minneapolis: University of Minnesota Press, 1958.

Culpepper, A. S. and A. C. York, *Weed Management in Glyphosate-Tolerant Cotton,* Journal of Cotton Science, 4(1998): p. 174-185.

Dawkins, K., *Towards a Biosafety Protocol,* Intellectual Property Rights (IPR) Info Sheets, Institute for Agriculture and Trade Policy (IATP), http://www.rz.uni-frankfurt.de/~ecstein/gen/biofacts.html, 1995, 4 p.

Dawkins, K., Thom, M., and Carr, C., *The Impact of Intellectual Property Rights on Biodiversity,* Intellectual Property Rights (IPR) Info Sheets, Institute for Agriculture and Trade Policy (IATP), http://www.rz.uni-frankfurt.de/~ecstein/gen/biofacts.html, 1995, 4 p.

Falck-Zepeda, J. B., Traxler, G., and Nelson, R. G., *Rent Creation and Distribution From Biotechnology Innovations: The Case of Bt Cotton and Herbicide-Tolerant Soybeans,* conference proceeding, Transitions in Agricultural Biotechnology: Economics of Strategy and Policy, Washington DC, June 24-25, 1999, 22 p.

Fernandez-Cornejo, J., Klotz-Ingram, C., and Jans, S., *Farm-Level Effects of Adopting Genetically Engineered Crops in the U.S.A.,* conference proceeding, Transitions in Agricultural Biotechnology: Economics of Strategy and Policy, Washington DC, June 24-25, 1999, 26 p.

Fetrow, J., *Economics Of Recombinant Bovine Somatotropin On U.S. Dairy Farms*, AgBioForum, vol. 2, http://www.agbioforum.missouri.edu, 1999, p. 103-110.

Foltz, J., Barham, B., and Kim, K., *Universities, Agricultural Biotechnology Patents, and Local Spillovers,* conference proceeding, Transitions in Agricultural

Biotechnology: Economics of Strategy and Policy, Washington DC, June 24-25, 1999, 33 p.

Freebairn, J. W., J. S. Davis, and G. W. Edwards, *Distribution of Research Gains in Multistage Production Systems,* American Journal of Agricultural Economics, 64(1982): p. 39-46.

Fulton, M. and Keyowski, L., *The Producer Benefits Of Herbicide-Resistant Canola*, AgBioForum, vol. 2, http://www.agbioforum.missouri.edu, 1999, p. 85-93.

Gianessi, L. P. and Carpenter, J. E., Agricultural Biotechnology: Insect Control Benefits, National Center for Food and Agricultural Policy (NCFAP), Washington, http://www.bio.org/food&ag/ncfap.htm, 1999, 101 p.

Griliches, Z., *Hybrid Corn: An Exploration in the Economics of Technological Change,* Econometrica, 25(1957): p. 501-522.

-----, *Research Costs and Social Returns: Hybrid Corn and Related Innovations,* Journal of Political Economics, 66(1958): p. 419-431.

-----, *The Sources of Measured Productivity Growth: United States Agriculture, 1940-60,* Journal of Political Economics, 71(1963): p. 331-346.

-----, *Research Expenditures, Education, and the Aggregate Agricultural Production Function,* American Economic Review, 54(1964): p. 961-974.

Hayenga, M. L., *Structural Change In The Biotech Seed and Chemical Industrial Complex*, AgBioForum, vol. 1, http://www.agbioforum.missouri.edu, 1999, p. 43-55.

Hicks, J. R., *The Theory of Wages,* London: MacMillan, 1932.

Hillyer, G., *Biotechnology Offers U.S. Farmers Promises And Problems*, AgBioForum, vol. 2, http://www.agbioforum.missouri.edu, 1999, p. 99-102.

Hoban, T. J., *Trends in Consumer Attitudes About Agricultural Biotechnology*, AgBioForum, vol. 1, http://www.agbioforum.missouri.edu, 1998, p. 3-7.

Holt, D. A. and Bullock, J. B., *Are Research Alliances Between Private Firms And Land Grant Universities Compatible With The Original Purpose?*, AgBioForum, vol. 2, http://www.agbioforum.missouri.edu, 1999, p. 11-16.

Horbulyk, T. M., *Strategy and Incentives in the Compulsory Licensing of Intellectual Property in Agriculture,* conference proceeding, Transitions in Agricultural Biotechnology: Economics of Strategy and Policy, Washington DC, June 24-25, 1999, 24 p.

Huffman, W. E. and Evenson, R. E., *Science for Agriculture: A Long-Term Perspective,* Ames IA: Iowa State University Press, 1993.

Hurley, T. M., Secchi, S., and Hellmich, R., *Managing the Risk of European Corn Borer Resistance to Transgenic Corn: An Assessment of Controversial Refuge Recommendations,* conference proceeding, Annual Meeting, August 8-11, 1999, 16 p.

Isaac, G. and Phillips, P. W. B., *Market Access and Market Acceptance For Agricultural Biotechnology Products,* conference proceeding, International Consortium on Agricultural Biotechnology Research (ICABR), CEIS - Tor Vergata University, Rome, June 17-19, 1999, 18 p.

James, C., Global Review of Commercialised Transgenic Cops: 1998*,* International Service for the Acquisition of Agri-Biotech Applications Briefs, Report n° 8, ISAAA, Ithaca NY, 1998.

Just, R. E. and D. L. Hueth, *Multimarket Exploitation: The Case of Biotechnology and Chemicals,* American Journal of Agricultural Economics*,* 75(1993): p. 936-945.

Kalaitzandonakes, N., *Public Acceptance of Agricultural Biotechnology: Editor's Introduction*, AgBioForum, vol. 1, http://www.agbioforum.missouri.edu, 1998, p. 1-2.

-----, *A Farm Level Perspective On Agrobiotechnology: How Much Value And For Whom?*, AgBioForum, vol. 2, http://www.agbioforum.missouri.edu, 1999, p. 61-64.

Kalaitzandonakes, N. and Marks, L. A., *Public Opinion of Agbiotech in the US and UK: A Content Analysis Approach,* conference proceeding, AAEA National Meetings Nashville, Tennesse, 1999, 14 p.

Kerr, W. A., Yampoin, R., and Hobbs, J. E., *The Trips Agreement and WTO Enforcement of Intellectual Property Rights in Agricultural Biotechnology,* conference proceeding, Transitions in Agricultural Biotechnology: Economics of Strategy and Policy, Washington DC, June 24-25, 1999, 16 p.

Kershen, D. L., *Biotechnology: An Essay On The Academy, Cultural Attitudes And Public Policy*, AgBioForum, vol. 2, http://www.agbioforum.missouri.edu, 1999, p. 137-146.

Klotz-Ingram, C. and Day-Rubenstein K., *The Changing Agricultural Research Environment: What does It Mean For Public-Private Innovation?*, AgBioForum, vol. 2, http://www.agbioforum.missouri.edu, 1999, p. 24-32.

Lavoie, B. F. and Sheldon, I. M., *The Source of Comparative Advantage in the Biotechnology Industry: A Real Options Approach,* conference proceeding, Transitions in Agricultural Biotechnology: Economics of Strategy and Policy, Washington DC, June 24-25, 1999, 17 p.

Lehman, K., *Pirates of Diversity: The Global Threat to the Earth's Seeds,* Intellectual Property Rights (IPR) Info Sheets, Institute for Agriculture and Trade Policy (IATP), http://www.rz.uni-frankfurt.de/~ecstein/gen/biofacts.html, 1994, 2 p.

Lesser, W., *Intellectual Property Rights and Concentration in Agricultural Biotechnology*, AgBioForum, vol. 1, http://www.agbioforum.missouri.edu, 1999, p. 56-61.

Lesser, W., Bernard, J. and Billah, K., *Methodologies for Ex Ante Projections of Adoption Rates for Agbiotech Products: Lessons Learned from rBST*, Agribusiness, vol. 15, 1999, p. 149-162.

Lindner, R. K. and F. G. Jarrett, *Supply Shifts and the Size of Research Benefits,* American Journal of Agricultural Economics*,* 60(1978): p. 48-56.

Loader, R. and Henson, S., *A View of GMO's From the UK*, AgBioForum, vol. 1, http://www.agbioforum.missouri.edu, 1998, p. 31-34.

Lyson, T., Tauer, L. W., and Welsh, R., Factors Related to the Adoption of rBST Among a Population of Farmers in Ontario County, New York*,* Report n° SP

95-01, Cornell University, Department of Agricultural Resources and Managerial Economics, Ithaca, NY, 1995.

Marra, M. C., Carlson, G. A., and Hubbell, B. J., *Economic Impacts of the First Crop Biotechnologies,* Electronic Publication, North Carolina Agricultural Research Service, University of Georgia Agricultural Experiment Station, USDA Southern Region Pesticide Impact Assessment Program, http://www.ag-econ.ncsu.edu/faculty/marra/online.html, 1998, 28 p.

Marshall, K. K., *What's In a Label?*, AgBioForum, vol. 1, http://www.agbioforum.missouri.edu, 1998, p. 35-37.

Mazoyer, M. and Roudart, L., *Histoire des agricultures du monde: du néolithique à la crise contemporaine,* Paris: Seuil, 1997, 535 p.

McBride, W. D. and Books, N., *Survey Evidence on Producer Use and Costs of Genetically Modified Seed,* conference proceeding, Transitions in Agricultural Biotechnology: Economics of Strategy and Policy, Washington DC, June 24-25, 1999, 25 p.

Meister, I. and Mayer, S., *Releases of Genetically Engineered Plants and Their Impacts on Less Developed Countries,* Intellectual Property Rights (IPR) Info Sheets, Institute for Agriculture and Trade Policy (IATP), http://www.rz.uni-frankfurt.de/~ecstein/gen/biofacts.html, 1995, 3 p.

Miller, H. I., *The Emotional Response to Risks: Inevitable But Not Unmanageable*, AgBioForum, vol. 1, http://www.agbioforum.missouri.edu, 1998, p. 14-16.

Moschini, G. and H. Lapan, *Intellectual Property Rights and the Welfare Effects of Agricultural R&D,* American Journal of Agricultural Economics*,* 79(1997): p. 1229-1242.

Norton, G. W. and J. S. Davis, *Evaluating Returns to Agricultural Research: A Review,* American Journal of Agricultural Economics*,* 63(1981): p. 685-699.

Perdikis, N., Kerr, W. A., and Hobbs, J. E., *Can the WTO/GATT Agreements on Sanitary and Phyto-Sanitary Measures and Technical Barriers to Trade Be Renegotiated to Accomodate Agricultural Biotechnology?,* conference proceeding, Transitions in Agricultural Biotechnology: Economics of Strategy and Policy, Washington DC, June 24-25, 1999, 24 p.

Persley, G. J., *Agricultural Biotechnology: Opportunities for International Development,* Biotechnology in Agriculture, vol. 2*,* Wallingford, UK: C.A.B. International, 1990, 495 p.

Phillips, P. W. B. and Isaac, G., *GMO Labeling: Threat or Opportunity?*, AgBioForum, vol. 1, http://www.agbioforum.missouri.edu, 1998, p. 25-30.

Rausser, G. C., *Public / Private Alliances*, AgBioForum, vol. 2, http://www.agbioforum.missouri.edu, 1999, p. 5-10.

Riley, P. A. and Hoffman, L., *Value-Enhanced Crops: Biotechnology's Next Stage*, Agricultural Outlook, 1999, p. 18-23.

Roberts, R. K., Pendergrass, R., and Hayes, R. M., *Farm-Level Economic Analysis of Roundup Ready (TM) Soybeans,* conference proceeding, Southern Agricultural Economics Association Meeting, Little Rock, Arkansas, February 1-4, 1998.

Schumpeter, J. A., *Capitalism, Socialism and Democracy,* New York: Harper, 1942.

Sianesi, B., *Species Loss Through the Genetic Modification of Crops - A Policy Framework,* conference proceeding, First World Congress of Resource and Environmental Economists, Venice, August 28, http://www.feem.it/gnee/libr.html, 1999, 29 p.

Sonka, A. and Pueppke, S., *Exploring The Public's Role In Agricultural Biotechnology Research*, AgBioForum, vol. 2, http://www.agbioforum.missouri.edu, 1999, p. 33-36.

Tauer, L. W. and W. A. Knoblauch, *The Empirical Impact of Bovine Somatotropin on New York Dairy Farms,* Journal of Dairy Science, 80(1997): p. 1092-1097.

Van Dusen, E., *Issues In the Release of Transgenic Crops In Developing Countries: The Mexican Case Study,* conference proceeding, International Consortium on Agricultural Biotechnology Research (ICABR), CEIS - Tor Vergata University, Rome, June 17-19, 1999, 14 p.

Wesseler, J., *Temporal Uncertainty and Irreversibility - A Theoretical Framework for the Decision to Approve the Release of Transgenic Crops,* conference proceeding, Transitions in Agricultural Biotechnology: Economics of Strategy and Policy, Washington DC, June 24-25, 1999, 15 p.

Zechendorf, B., *Agricultural Biotechnology: Why Do Europeans Have Difficulty Accepting It?*, AgBioForum, vol. 1, http://www.agbioforum.missouri.edu, 1998, p. 8-13.

Zepeda, L., Douthitt, R., and You, S.-Y., *Consumer Acceptance of Agricultural Biotechnology: The Role of Labeling and Risk Perceptions On Food Demand,* conference proceeding, International Consortium on Agricultural Biotechnology Research (ICABR), CEIS - Tor Vergata University, Rome, June 17-19, 1999, 14 p.

Zilberman, D. and Yarkin, C., *Agricultural Biotechnology, Intellectual Property Rights and Biodiversity,* conference proceeding, International Consortium on Agricultural Biotechnology Research (ICABR), CEIS - Tor Vergata University, Rome, June 17-19, 1999.

Zilberman, D., Yarkin, C., and Heiman, A., *Agricultural Biotechnology: Economic and International Implications,* Proceedings Twenty-third International Conference of Agricultural Economists, vol. Ashgate, 1999, 161 p.

[1] Gene stacking involves combining traits (e.g. herbicide tolerance and insect resistance) in seed (Anonymous, 1999).

[2] literally translated from the French term “chimisation” used by Mazoyer and Roudart (1997)

List of Available Working Papers

nr. 1 BEERLANDT, H. en L. DRIESEN, *Criteria ter evaluatie van 'duurzame landbouw'*, Afdeling Landbouweconomie, K.U.Leuven, januari 1994, 35 p.

nr. 2 BEERLANDT, H. en L. DRIESEN, *Evaluatie van herbicide-resistente planten aan criteria voor duurzame landbouw,* Afdeling Landbouweconomie, K.U.Leuven, januari 1994, 39 p.

nr.3 BEERLANDT, H. en L. DRIESEN, *Evaluatie van bovine somatotropine aan criteria voor duurzame landbouw*, Afdeling Landbouweconomie, K.U.Leuven, januari 1994, 63 p.

nr. 4 BEERLANDT, H. en L. DRIESEN, *Evaluatie van gemanipuleerde planten met biopesticide eigenschappen afkomstig van Bacillus thuringiensis aan criteria voor duurzame landbouw,* Afdeling Landbouweconomie, K.U.Leuven, januari 1994, 32 p.

nr. 5 BEERLANDT, H. en L. DRIESEN, *Evaluatie van haploide planten aan criteria voor duurzame landbouw,* Afdeling Landbouweconomie, K.U.Leuven, januari 1994, 17 p.

nr. 6 BEERLANDT, H. en L. DRIESEN, *Evaluatie van genetische technieken voor diagnosebepaling, immunologische technieken ter verbetering van de landbouwproduktie en transgene dieren en planten als bioreactor aan criteria voor duurzame landbouw,* Afdeling Landbouweconomie, K.U.Leuven, januari 1994, 28 p.

nr. 7 BEERLANDT, H. en L. DRIESEN, *Evaluatie van verbetering van de stikstoffixatie bij planten aan criteria voor duurzame landbouw,* Afdeling Landbouweconomie, K.U.Leuven, januari 1994, 17 p.

nr. 8 BEERLANDT, H. en L. DRIESEN, *Evaluatie van porcine somatotropine aan criteria voor duurzamelandbouw,* Afdeling Landbouweconomie, K.U.Leuven, januari 1994, 29 p.

nr. 9 BEERLANDT, H. en L. DRIESEN, *Evaluatie van tomaten met een langere houdbaarheid aan criteria voor duurzame landbouw,* Afdeling Landbouweconomie, K.U.Leuven, februari 1994, 30 p.

nr. 10 CHRISTIAENSEN, L., *Voedselzekerheid: van concept tot actie: een status questionis,* Afdeling Landbouweconomie, K.U.Leuven, april 1994, 106 p.

nr. 11 CHRISTIAENSEN, L. and J. SWINNEN, *Economic, Institutional and Political Determinants of Agricultural Production Structures in Western Europe,* Afdeling Landbouweconomie, K.U.Leuven, May 1994, 40 p.

nr. 12 GOOSSENS, F., *Efficiency and Performance of an Informal Food Marketing System, The case of Kinshasa, Zaire,* Afdeling Landbouweconomie, K.U.Leuven, July 1995, 41 p.

nr. 13 GOOSSENS, F., *Failing Innovation in the Zairian Cassava Production System, A comparative historical analysis,* Afdeling Landbouweconomie, K.U.Leuven, July 1995, 18 p.

nr. 14 TOLLENS, E., *Cadre conceptuel concernant l'analyse de la performance économique des marchés,* Projet-FAO "Approvisionnement et Distribution Alimentaires des Villes de l'Afrique Francophone", Afdeling Landbouweconomie, K.U.Leuven, août 1995, 35 p.
(Deuxieme version, avril 1996)

nr. 15 TOLLENS, E., *Les marchés de gros dans les grandes villes Africaines, diagnostic, avantages et éléments d'étude et de développement,* Projet-FAO "ApprovisioMement et Distribution Alimentaires des Villes de l'Afrique Francophone", Afdeling Landbouweconomie, K.U.Leuven, août 1995, 23 p.
(Deuxieme version, septembre 1996, 32 p.)

nr. 16 ENGELEN, G., *Inleiding tot de landbouwvoorlichting* (heruitgave), Afdeling Landbouweconomie, K.U.Leuven, augustus 1995, 17 p.

nr. 17 TOLLENS, E., *Agricultural Research and Development towards Sustainable Production Systems: I. Information Sources, Surveys; II. Conceptualisation of the Change Process,* NATURA-NECTAR course: "Agricultural Economics and Rural Development", module 1, Afdeling Landbouweconomie, K.U.Leuven, August 1995

nr. 18 TOLLENS, E., *Planning and Appraising Agricultural Development programmes and Projects: I. Farm Planning; II. Aggregation, Sensitivity Analyses and Farm Investment Analysis; III. Guidelines on Informal Surveys and Data Collection,* NATURA-NECTAR course: "Agricultural Economics and Rural Development", module 2, Afdeling Landbouweconomie, K.U.Leuven, September 1995

nr. 19 TOLLENS, E., *Structural Adjustment and Agricultural Policies: I. Market Theory: the State and the Private Sector; II. Output Markets and Marketing Institutions; III. Input Markets; IV. Case Study: Cameroon,* NATURA-NECTAR course: "Agricultural Economics and Policy Reforms", module 1, Afdeling Landbouweconomie, K.U.Leuven, September 1995

nr. 20 TOLLENS, E., *Theory and Macro-Economic Measures of Structural Adjustment – Methods of Evaluation and Linkages to the Agricultural Sector: I. Development Models and the Role of Agriculture,* NATURA-NECTAR course: "Agricultural Economics and Policy Reforms", module 2, Afdeling Landbouweconomie, K.U.Leuven, September 1995 nr. 21 TOLLENS, E., *Theory and Macro-Economic Measures of Structural Adjustment – Methods of Evaluation and Linkages to the Agricultural Sector: II. Implementation of Policy Reforms: Case Study of Market Liberalisation in Cameroon for Cocoa and Coffee,* NATURA-NECTAR course: "Agricultural Economics and Policy Reforms", module 2, Afdeling Landbouweconomie, K.U.Leuven, September 1995

nr. 22 TOLLENS, E., *Supply Response within the Farming Systems Context: I. Input Supply and Product Markets; II. Agricultural Supply Response Assessment,* NATURA-NECTAR course: "Agricultural Economics and Policy Reforms", module 3, Afdeling Landbouweconomie, K.U.Leuven, September 1995

nr. 23 GOOSSENS, F., *Agricultural Marketing and Marketing Analysis: I. Agricultural Marketing Research Frameworks. II. Agricultural Market Performance Criteria and The Role of Government Intervention,* NATURA-NECTAR course: "Agricultural Economics and Rural Development", module 3, Afdeling Landbouweconomie, K.U.Leuven, September 1995

nr. 24 GOOSSENS, F., *Agricultural Marketing and Marketing Analysis: Demand Analysis,* NATURA-NECTAR course: "Agricultural Economics and Rural Development", module 3, Afdeling Landbouweconomie, K.U.Leuven, September 1995

nr. 25 CHRISTIAENSEN, L. en H. BEERLANDT, *Belgische voedselhulp geanalyseerd met betrekking tot voedselzekerheid,* Afdeling Landbouweconomie, K.U.Leuven, november 1994, 15 p.

nr. 26 CHRISTIAENSEN, L. en H. BEERLANDT, *De Belgische ontwikkelingssamenwerking met Rwanda geanalyseerd met betrekking tot voedselzekerheid,* Afdeling Landbouweconomie, KU.Leuven, november 1995, 36 p.

nr. 27 BEERLANDT, H., *Identificatie van de meest kwetsbaren in Monduli distrikt, Arusha regio, Tanzania,* A.C.T.- Afdeling Landbouweconomie, K.U.Leuven, april 1995, 40 p.

nr. 28 BEERLANDT, H., TOLLENS, E. and DERCON, S., *Methodology for Addressing Food Security in Development Projects, Identification of the Food Insecure and the Causes of Food Insecurity based on Experiences from the Region of Kigoma, Tanzania,* Department of Agncultural Economics and Centre for Economic Research, K.U.Leuven, Leuven, December 1995, 19 p.

nr. 29 BEERLANDT, H., *Koppelen van noodhulp en strukturele ontwikkelingssamenwerking: opties voor een Belgisch beleid,* Afdeling Landbouweconomie, K.U.Leuven, december 1995, 23 p.

nr.30 TOLLENS, E., *La crise agraire au Zaïre: pour quelle politique de développement dans la phase de transition?,* Une contribution au colloque "Le Zaïre en Chantier: Quels Projets de Societé", Anvers, 18 février 1993, 14 p.

nr.31 GOOSSENS, F., *Rôle des systemes d'alimentation dans la securité alimentaire de Kinshasa,* Une contribution au projet GCP/RAF/309, AGSM, FA0, mai 1996, 78 p.

nr.32 BEERLANDT, H., DERCON, S., and SERNEELS, I., (Project co-ordinator: E. TOLLENS), *Tanzania, a Food Insecure Country?,* Department of Agricultural Economics, Center for Economic Research, K.U.Leuven, September 1996, 68 p.

nr. 33 TOLLENS, E., *Food security and nutrition 2. Case study from Tanzania,* Nectar Programme, Agricultural Economics and Policy Reforms, module 4, Afdeling Landbouweconomie, K.U.Leuven, Septembre 1996, 47 p.

nr. 34 BEERLANDT, H., en SERNEELS, J., *Voedselzekerheid in de regio Kigoma, Tanzania,* Afdeling Landbouweconomie en Centrum voor Economische Studiën, K.U.Leuven, september 1996, 45 p.

nr. 35 BEERLANDT, H., *Identificatie van verifieerbare indicatoren ter toetsing van de voedselzekerheidssituatie in de regio Arusha, Tanzania,* Afdeling Landbouweconomie, K.U.Leuven, november 1996, 60 p.

nr. 36 GOOSSENS, F., *Commercialisation des vivres locaux en Afrique Subsaharienne, le secteur informel dans un perspectif dynamique,* Une contribution au projet GCP/RAF/309, AGSM, FAO, novembre 1996, 58 p.

nr. 37 GOOSSENS, F., *The Economics of Livestock Systems: I. Marketing Problems and Channels of Livestock in Subsahara Africa,* NATURA-NECTAR course: "Agricultural Economics and Rural Development", module 4, Afdeling Landbouweconomie, K.U.Leuven, November 1996.

nr. 38 GOOSSENS, F., *The Economics of Livestock Systems: II. Price Stabilization in the Livestock Sector,* NATURA-NECTAR course: "Agricultural Economics and Rural Development", module 4, Afdeling Landbouweconomie, K.U.Leuven, November 1996.

nr.39 GOOSSENS, F., *The Economics of Livestock Systems: III. Consumer Demand for Livestock Products,* NATURA-NECTAR course: "Agricultural Economics and Rural Development, module 4, Afdeling Landbouweconomie, K.U.Leuven, November 1996.

nr. 40 JASPERS, N., *I. La Seguridad Alimenticia en el departamento de Quiché: Identificación e Impacto del Programa de Créditos, II. Informe Sobre Estudio Seguridad Alimenticia,* ACT - Afdeling LandbwAuweconomie, K.U.Leuven, November 1996, 39 p.

nr. 41 TOLLENS, E., *Social indicators with an illustration from Thailand,* NATURA-NECTAR course: "Agricultural Economics and Policy Reforms", module 4, Afdeling Landbouweconomie, K.U.Leuven, January 1997, 38 p.

nr. 42 BEERLANDT, H., en SERNEELS, J., *Handleiding voor een voedselzekerheidsdiagnose,* Afdeling Landbouweconomie en Centrum voor Economische Studiën, K.U.Leuven, februari 1997, 131 p.

nr. 43 BEERLANDT, H., and SERNEELS, J., *Manual for a Food Security Diagnosis,* Department of Agricultural Economics and Center for Economic Research, K.U.Leuven, March 1997, 125 p.

nr. 44 GOOSSENS, F., *Aangepaste vormen van samenwerking als hefboom voor de sociaal-economische promotie van boeren in het zuiden - algemene conclusies,* Seminarie georganizeerd door Ieder Voor Allen, Brussel, 17-18 maart 1997, 8 p.

nr. 45 GOOSSENS, F., *Commercialisation des vivres locaux en Afrique Subsaharienne - neuf études de cas,* Afdeling Landbouweconomie, K.U.Leuven, Mai 1997, 50 p.

nr. 46 BEERLANDT, H., en SERNEELS, J., *Food Security in the Kigoma Region of Tanzania,* Department of Agricultural Economics and Center for Economic Research, K.U.Leuven, May 1997, 42 p.

nr. 47 BEERLANDT, H., and SERNEELS, J., *Manual Pour un Diagnostic de Securité Alimentaire,* Département d'Economie Agricole et le Centre d'Etudes Economiques, K.U.Leuven, Juillet 1997, 134 p.

nr. 48 GOOSSENS, F., *Rural Services and Infrastructure - Marketing Institutions,* NATURA-NECTAR course: "Agricultural Economics and Policy Reforms", module 4, Afdeling Landbouweconomie, K.U.Leuven, June 1997, 20 p.

nr. 49 TOLLENS, E., *International Trade and Trade Policy in Livestock and Livestock Products,* NATURA-NECTAR COURSE: "Agricultural Economics and Rural Development", module 4, Afdeling Landbouweconomie, K.U.Leuven, October 1997,43 p.

nr. 50 DESMET, A., *Working towards autonomous development of local farmer organisations: which role for development agencies?,* Department of Agricultural Economics and Center for Economic Research, March 1998, 49 p.

nr. 51 TOLLENS, E., *Catalogue de titres dans la bibliotheque ALEO sur le Zaïre - Congo,* Département d'Economie Agricole, Mars 1998, 96 p.

nr. 52 DEMONT, M., JOUVE, P., STESSENS, J., et TOLLENS, E., *Evolution des systèmes agraires dans le Nord de la Côte d'Ivoire: les débats « Boserup versus Malthus » et « compétition versus complémentarité » révisités*, Département d'Economie Agricole et de l'Environnement, K.U.Leuven, Avril 1999, 43 p.

nr. 53 DEMONT, M., and TOLLENS, E., *The Economics of Agricultural Biotechnology: Historical and Analytical Framework*, Department of Agricultural and Environmental Economics, K.U.Leuven, October 1999, 47 p.

nr. 54 DEMONT, M., en TOLLENS, E., *Biologische, biotechnologische en gangbare landbouw : een vergelijkende economische studie*, Afdeling Landbouw- en Milieueconomie, K.U.Leuven, Maart 2000, 53 p.

nr. 55 DEMONT, M., JOUVE, P., STESSENS, J., and TOLLENS, E., *The Evolution of Farming Systems in Northern Côte d'Ivoire: Boserup versus Malthus and Competition versus Complementarity*, Department of Agricultural and Environmental Economics, K.U.Leuven, August 2000, 25 p.

nr. 56 DEMONT, M., and TOLLENS, E., *Economic Impact of Agricultural Biotechnology in the EU: The EUWAB-project*, Department of Agricultural and Environmental Economics, K.U.Leuven, January 2001, 16 p.

nr. 57 DEMONT, M., and TOLLENS, E., *Reshaping the Conventional Welfare Economics Framework for Estimating the Economic Impact of Agricultural Biotechnology in the European Union*, Department of Agricultural and Environmental Economics, K.U.Leuven, March 2001, 32 p.

nr. 58 DEMONT, M., and TOLLENS, E., *Uncertainties of Estimating the Welfare Effects of Agricultural Biotechnology in the European Union*, Department of Agricultural and Environmental Economics, K.U.Leuven, April 2001, 81 p.

nr. 59 DEMONT, M., and TOLLENS, E., *Welfare Effects of Transgenic Sugarbeets in the European Union: A Theoretical Ex-Ante Framework*, Department of Agricultural and Environmental Economics, K.U.Leuven, May 2001, 36 p.