Did the Economic Conditions for Bt-maize in the EU Improve from 1995 to 2004? A MISTICs Perspective.

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A MISTICs Perspective.

Abstract:
The debate about the "quasi" moratorium on the release of GMOs in the European Union is on going. One of the major arguments that were put forward to delay the release of new traits was the one for more information. In this contribution we compare the situation for Bt-maize from the 1995 and 2004 perspective. The 2004 perspective differentiate between two scenarios: one without the CAP reform and one including the CAP reform. For the comparison we use an ex-ante assessment model based on real option theory that explicitly considers the irreversible costs and benefits of the technology. As empirical information about possible irreversible costs is scarce we identify the maximum incremental social tolerable irreversible costs, MISTICs, for Bt-maize, a threshold value beyond which the immediate release of the crop should be delayed. The reversible benefits from Bt-maize among the EU-15 where the damage from the ECB is economically important namely France, Greece, Italy, Spain, and Portugal are modeled using a small open economy partial equilibrium model.
We compare the MISTICs for those five countries by farm household and by household. We observe very low values at household level, which have only slightly changed in favor of an immediate EU-wide release of Bt-maize. The CAP-reform in the case for Bt-maize does decrease the economic incentives for immediate adoption. Further details are discussed in the main text.

Keywords: Bt-maize, irreversibility, real options, uncertainty

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1. Introduction

The EU-15 produces about 3% of the world's maize. The maize production is concentrated in France (40%), immediately followed by Italy (30%). The EU-15 also is a net importer of maize for human consumption, 6.4% of its consumption is imported (mainly from Argentina - 4%, and Hungary - 2%), while only 0.4% of domestic production is exported outside the EU-15.

Maize is grown in the EU-15 mainly for animal feed (80%). Maize for human consumption (20%) is used to produce maize oil, starch and sweeteners which are common ingredients in many processed foods such as breakfast cereals and dairy goods, and only a small amount is used for direct consumption (see Essential Biosafety, 2004; EUROSTAT, 2005). Bt maize in the EU is currently grown in Spain with an adoption rate of about 17.5% (0.1 million hectares), and a small amount in Germany and France (James, 2004). Bt maize is expected to benefit farmers through reduced harvest losses due to European Corn Borer (ECB) infestation. Bt maize is also expected to benefit the environment through reduced insecticide use.[1] In addition, due to the protection of Bt varieties against physical insect damage, it has been widely reported that Bt varieties are associated with a lower incidence of secondary Fusarium contamination (e.g. Wu et al., 2004). At the same time, due to higher costs for Bt-seeds, it is not undisputed that the associated yield improvements will also translate in increased farmer income. The development of ECB resistance against Bt due to the commercialization of Bt maize, furthermore, might reduce the benefits of the technology (Hurley, 2005; Laxminarayan and Simpson, 2005) and be a problem for organic farmers who currently use Bt-sprays, as a natural crop protection tool (Demont and Tollens, 2004).

[1] This is of lesser importance as many farmers do not control for the ECB due to the mentioned management problems.

The decision to release a new crop such as Bt-maize in the EU involves both uncertainty and irreversibility (Morel et al., 2003; Wesseler, 2003). The social planner, in this case the EU, has to decide whether to release a transgenic crop immediately or to postpone the release until further information about benefits and costs of the new crop is available.

In this paper the objective is to see whether or not the situation for releasing Bt-maize immediately has changed, if we compare the situation of the year 1995 with the one in the year 2004 for the EU-15 member states where the damage from the ECB is economically important namely France, Greece, Italy, Spain, and Portugal. For the year 2004 perspective we differentiate between two scenarios: one without the CAP reform and one including the CAP reform. Following the approach by Demont et al. (2004) and Scatasta et al. (2005) we use an ex-ante assessment model based on real option theory that explicitly considers the irreversible costs and benefits of the technology and calculate the maximum incremental social tolerable irreversible costs, MISTICs, for Bt-maize. The MISTIC is a threshold value beyond which the immediate release of the crop should be delayed. The reversible benefits from Bt-maize among the EU-15 are modeled using a small open economy partial equilibrium model.

2. The real option approach

Defining the maximum incremental social tolerable irreversible costs (MISTIC)

The decision-maker is assumed to compare the benefits of an immediate release with those from a postponed decision. Only if the benefits of an immediate release, the *value of the release*, outweigh those of the *option to release*, should the option to release be exercised.

In the case of GMOs it is important to differentiate between the incremental reversible and irreversible benefits and costs at private as well as the public level. In general, information about potential benefits and costs from GMOs, even so they are uncertain, are available from field trials and experiences in other countries. Also, information about incremental irreversible benefits is available such as health and environmental benefits from changes in pesticide and fuel use. Less information is available about the irreversible costs, such as impacts on biodiversity and ecosystems in general. The situation is summarized in figure 1. Under these circumstances the *real option* decision criteria can be stated as the maximum incremental social tolerable irreversible costs (*I**) to be no greater than the sum of the incremental irreversible social benefits (*R*) and reversible social net-benefits (*W*) from GM crops weighted by the hurdle rate $\beta/(\beta-1)$ (Wesseler, 2003):

$$I^* \leq \frac{W}{\beta/(\beta-1)} + R \text{, with } \beta = \frac{1}{2} - \frac{r-\delta}{\sigma^2} + \sqrt{\left[\frac{r-\delta}{\sigma^2} - \frac{1}{2}\right]^2 + \frac{2r}{\sigma^2}} > 1 \qquad (1)$$

where r is the riskless rate of return, δ the convenience yield defined as $\delta = \mu - \alpha$ with μ as the risk adjusted rate of return and α the drift rate of a geometric Brownian motion,[2] σ the variance rate of a geometric Brownian motion and β the positive root of the solution for a Fokker-Planck equation. Since $\left[\beta/(\beta-1)\right] > 1$, the *real option* decision criteria is more restrictive than the *traditional* decision criteria $I^* \leq W + R$.

The use in practice of the *real option* decision criteria specified in (1) requires quantification of the social incremental reversible benefits from GM crops (SIRB), *W*, the hurdle rate, $\beta/(\beta-1)$, and the social incremental irreversible benefits (SIIB), *R*. In the following sections the quantification of these three factors for Bt maize will be discussed. We will present the approach used to calculate the 1995 values but the values for 2004 have been calculated in a similar way.

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[2] Lognormality of the Brownian motion is not a problem, assuming technology adopters can temporarily suspend planting HT sugar beet and plant non-HT sugar beet instead, without bearing any additional costs. This follows from Dixit and Pindyck (1994), pp. 187-189.

Defining the social incremental reversible net benefits SIRB

The value of *SIRB* for EU country *i* over time will be given by the present value of those benefits such that:

$$SIRB_i = SIRB_{i,95} = \int_0^{\infty} SIRB_i(t)e^{-\mu t}dt \qquad (2)$$

where $\mu = 10.5$ is the capital asset pricing model (CAPM) risk adjusted rate of return as in Demont et al. (2004).

$SIRB_i$ at time *t*, $SIRB_i(t)$, will be given by the maximum amount of social incremental reversible net-benefits obtainable at time *t* at complete adoption, $SIRB_{i,MAX}(t)$, times the adoption rate at time *t*, $\rho(t)$, such that:

$$SIRB_i(t) = SIRB_{i,MAX}(t)\rho(t) \qquad (3)$$

As we were not able to identify, based on the available literature, non-private reversible net-benefits of transgenic maize, in this study the maximum amount of $SIRB_i$ obtainable at time *t* at complete adoption, $SIRB_{i,MAX}(t)$, and the present value of $SIRB_i$ over time only entails private reversible net-benefits. To quantify the maximum amount of $SIRB_i$ obtainable at time *t* at complete adoption, $SIRB_{i,MAX}(t)$, we consider the market for grain maize in the EU-15.

In our base scenario, scenario 1, the model is framed to recognize the presence of the price support system for grain maize provided, through a regime of levies and export subsidies, by the European Common Agricultural Policy (CAP). This price support system implies that the price paid by grain maize buyers, is lower than that received by grain maize sellers (Katranidis and Velentzas, 2000). Base price and quantities used refer to the year 1995, hurdle rates are calculated based on time series data on the value of production from 1973 to 1995 (the monetary unit is 2004 Euro).

In scenario 2, base price and quantities for 2004 are used instead. Hurdle rates are calculated based on time series data from 1973 to 2004. The comparison between scenario 1 and 2 will give some insights about the change of expected benefits and costs over time and on how this change affects the value of *SIRB*, *SIIB*, and the *MISTIC*.

In scenario 3, the same base price and quantities as well as hurdle rates of scenario 2 are used, but the model is modified to consider the CAP reform eliminating the price support system for maize. Comparison between scenario 2 and 3 will give us some insights on the ability (or inability) of the CAP-reform to provide incentives for the adoption of new technologies.

We consider two sets of market agents: buyers and sellers. We limit the analysis to two types of technologies, transgenic and conventional, without taking organic production into consideration.

As suggested in Moschini and Lapan (1997), the grain maize supply function is best represented in constant elasticity form with parameters specific to the transgenic technology. As EU-15 member States are mainly small importers of grain maize, to consider the case of a small open economy the demand for grain maize is modeled perfectly elastic (Demont and Tollens, 2004). We assume that consumers with revealed preferences for non-GM products are the same consumers that buy organic products. Therefore, we do not expect a shift in demand with the introduction of GM grain maize and consider a pooled market for grain maize.

Defining the social incremental irreversible benefits (SIIB) R

In calculating the SIIB we follow Scatasta et al. (2003) and refer the interested reader to their publication and just report their findings adjusted to our case using the base year 2004.

Data

The data used for this analysis are from EUROSTAT New Cronos Database (ECD) (EUROSTAT). From ECD we obtained data on produced quantities and output prices for grain maize. Output prices received by maize sellers include subsidies to agricultural producers. The supply and demand elasticities are taken from secondary literature souirce as indicated in Table 1.

Data for estimating the *Bt* maize adoption curve was obtained from ISAAA. Data for estimating the proportionate vertical supply shift, *K*, in the supply function for *Bt* maize was obtained from field trials from the EU funded ECOGEN project in Narbonne, France.

Variable operational costs for conventional technology are calculated as the average over the eight plots managed with the conventional technology using conventional seeds. The average value of variable costs over three plots (one plot was destroyed by protestors) managed with the Bt technology was used as the indicator for the costs of the Bt technology.

Estimates of the adoption curves for *Bt* maize were obtained assuming an adoption rate ceiling of 30% for *Bt* maize but with half the speed of the U.S. adoption:[3]

$$\ln\left(\frac{\theta(t)}{0.3-\theta(t)}\right)_{Bt} = 2.41 - 0.335t \tag{4}$$

Given the information in Equation (4) we computed the *SIRB* of *Bt* maize as the sum of the changes for the EU-15 in producer and consumer surplus assuming no change in the buyers' demand for maize. We also assumed that *Bt* maize would be adopted only in France, Italy, Portugal, Spain and Greece.

For estimating the drift rate, α, and the variance rate, σ, of the new technology, we compute the maximum likelihood estimator assuming continuous growth (Campbell et al., 1997). We use time-series data on annual gross revenue differentials in maize production

[3] The original estimated speed of adoption was 0.67 for Bt maize.

from 1987 to 1995 and 2004 respectively as a proxy for estimating the drift and variance rate of the geometric Brownian motion. All monetary data are deflated and converted into real terms for the base year 2004 using the GDP deflators published by EUROSTAT (2005). Data on areas planted to maize, numbers of maize holdings, and currency rates are extracted from the ECD, while household data are reported by the EEA (2001).

Results and Discussion

The results per country and for the EU-15 are presented in Table 3 to Table 6. Table 3 shows the hurdle rate for the year 1995 and 2004. For the EU the hurdled rate has decreased indicating a more favourable situation for Bt-maize, while the situation at the country level differs. While for France and Spain the hurdle rates decreased, they increased for Greece, Italy, and Portugal albeit only slightly.

MISTIC and SIRB for the EU-15

The results indicate that the expected *SIRB* per hectare actually decreased comparing the situation of 1995 with 2004. The CAP reform further decreases the benefits from maize production as farmers loose the direct subsidies in this particular case, the small open economy. The situation will most-likely look different for other crops such as fodder maize. The MISTICs at household level only decrease by a small amount at EU level. If one adopts the view that the willingness-to-pay to not have Bt-maize allowed for planting in the EU, than the situation has further moved against Bt-maize. On the other hand, the situation at EU level has changed more in favor of the technology at maize growing farm household level. This contrary developments can be explained by the decrease in the number of maize growing farm households.

The results also demonstrate that even so the MISTICs at household level are extremely small at country level they reach millions per year.

Implications for regulating the release of GMOs in the European Union

As GMOs will be released only if considered safe for human consumption, the major regulatory issues concerning their release are issues related to environmental impacts of GM crops (e.g. impacts on biodiversity) and issues of co-existence with non-GM crops (e.g. pollen flow). Space does not allow us to discuss those issues in detail. The interested reader is referred to Beckmann, Soregaroli and Wesseler (2005) for a discussion on the implication of co-existence rules and regulations in the EU on the adoption of GMOs. Here we merely report the information our analysis can provide for the discussion.

In Europe there are three type of rules and regulations evolving for governing the co-existence of non-GM and GM crops. Spain currently has almost no rules and regulations and farmers can grow Bt maize without having to comply with additional planting requirements that differ from non-GM maize. In Denmark farmers have to register areas allocated to GM crops, keep a minimum distance to neighboring non-GM crops and have to pay a certain amount into a trust fund that will be used to compensate for any damages. In Germany GM farmers need to register all their areas allocated to GM crops in a publicly available database, have to keep a minimum distance to neighboring non-GM crops and will be liable for any damages to non-GM farmers under a system of joint liability. Other EU member states are still developing their own co-existence laws that either follows the Danish or the German model. The *SIRBs* per hectare provide a first indicator about the maximum costs farmers are willing to bear for complying with regulations. Based on our analysis adopting farmers will not be willing to pay more than about 78€ per hectare to comply with co-existence rules and regulations for Bt-maize.

Conclusion

In this study we estimated the *MISTIC*, the maximum incremental social tolerable irreversible costs, associated with the immediate adoption of Bt maize in the EU 15 using a real option approach and data from field trials carried out in 2004 in Narbonne, France. The *MISTIC* is an amount that would cover irreversible benefits from Bt maize and irreversible private net-benefits weighted by an estimated hurdle rate.

SIRB, social incremental reversible benefits, accruing to producers of Bt-maize were found to decrease due to the CAP reform. It would be interesting to extend the analysis including other crops as well. First steps in that direction have been initiated.

The low *MISTIC* per household for over all countries included in the analysis provides a strong economic argument for prohibiting the immediate introduction Bt-maize. This situation did not much change from 1995 to 2004. However, consumer attitudes may change over time, e.g. if scientific evidence shows higher environmental benefits or lower irreversible costs of transgenic crops.

A note for the reviewers: The results are based on hurdle rates calculated using gross revenues. They will be up-dated for the final version using the FADN data-set of the EU which provides gross margins and will provide a better source for the calculation of the hurdle rate. Therefore, the results may change, but we expect only small changes. We have been promised to get access to the data-set by early December.

References

Achilles, D., 2005. GMO Situation in Germany 2005. GAIN Report GM501, U.S. Department of Agriculture, Washington, DC.

Banse, M., H. Grethe, Nolte, S., 2004. European Simulation Model (ESIM) in GAMS: User Handbook. Göttingen and Berlin.

Beckmann, V., C. Soregaroli and J. Wesseler. "Coase and Co-existence Under Irreversibility and Uncertainty." Unpublished, Wageningen University, 2005.

Campbell, J.Y., Lo, A.W., MacKinlay, A.C., 1997. The Econometrics of Financial Markets. Princeton University Press, Princeton, 611 pp.

Demont, M., Tollens, E., 2004. First Impact of Biotechnology in the EU: Bt Corn Adoption in Spain. Annals of Applied Biology 145, 197-207.

Demont, M., Wesseler J., Tollens, E., 2004. Biodiversity versus transgenic sugar beet: the one euro question. European Review of Agricultural Economics 31, 1-18.

Demont, M., Wesseler J., Tollens, E., 2005. Reversible and irreversible costs and benefits of transgenic crops. In: Wesseler, J. (Ed.), Environmental Costs and Benefits of Transgenic Crops. Dordrecht, Springer, pp. 113-122.

Dixit, A.K., Pindyck, R.S., 2004. Investment under Uncertainty. Princeton University Press, Princeton, 476 pp.

EEA, 2001. Household Number and Size. European Environment Agency, Copenhagen.

Essential Biosafety, 2004. Crop Database: DBT418. Available at http://www.essentialbiosafety.info/dbase.php?action=ShowProd&data=DBT418. (database online) (Cited: 21 February, 2005).

Eurostat, 2005. Eurostat New Cronos database (theme 5). Available at http://europa.eu.int/newcronos. (database online). Updated October 2005.

Hurley, T., 2005. *Bacillus thuringiensis* resistance management: experiences from the USA. In: Wesseler, J. (Ed.), Environmental Costs and Benefits of Transgenic Crops. Dordrecht, Springer, pp. 81-94.

James, C., 2004. Global Status of Commercialized Biotech/GM Crops 2004. International Service for the Acquisition of Agri-Biotech Applications (ISAAA) Briefs No. 32-2004, Ithaca.

Katranidis, S., Velentzas, K., 2000. The Markets of Cotton Seeds and Corn in Greece: Welfare Implications of the Common Agricultural Policy. *Agricultural Economic Review* 1:80-95.

Laxminarayan, R., Simpson, D., 2005. Biological limits on agricultural intensification: an example from resistance management. In: Wesseler, J. (Ed.), Environmental Costs and Benefits of Transgenic Crops. Dordrecht, Springer, pp. 47-60.

Lekakis, J.N., and C. Pantzios. “Agricultural Liberalization and the Environment in Southern Europe: the Role of the Supply Side.” *Applied Economics Letters* 6 (7):453-58.

Morel, B., Farrow, S. Wu, F., Casman, E., 2003. Pesticide resistance, the precautionary principle, and the regulation of *Bt* Corn: real option and rational option approaches to decision-making. In: Laxminarayan, R. (Ed.) Battling Resistance to Antibiotics and Pesticides, Resources for the Future, Washington, D.C., pp.184-213.

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

Soregaroli, C., Wesseler, J., 2005. The farmer’s value of transgenic crops under ex-ante regulation and ex-post liability. In: Wesseler, J. (Ed.), Environmental Costs and Benefits of Transgenic Crops. Dordrecht, Springer, pp.165-182.

Wesseler, J. 2003. Resistance economics of transgenic crops. A real option approach. In: Laxminarayan, R. (Ed.) Battling Resistance to Antibiotics and Pesticides, Resources for the Future, Washington, D.C., pp. 214-237.

Wu, F., J.D. Miller, and E.A. Casman. “The Economic Impact of Bt Corn Resulting from Mycotoxin Reduction.” *Journal of Toxicology-Toxin Reviews* 23(2004):397-424.

Table 1: Base Demand and Supply elasticities for grain maize.

Country	Source for Supply elasticity	Demand elasticity	Supply elasticity
France	Banse et al. (2004)	infinity	0.77
Greece	Katranidis and Valentzas (2000)	infinity	0.60
Italy	Banse et al. (2004)	infinity	0.77
Portugal	Lekakis and Pantzios (1999)	infinity	2.50
Spain	Lekakis and Pantzios (1999)	infinity	2.50

Table 2: Base Price and Quantities for Grain Maize.

Country	Price without subsidy 1995	Price with subsidy 1995	Quantity 1995	Price without subsidy 2004	Price with subsidy 2004	Quantity 2004
Measurement unit	’04 Euro/100kg		1000 t	’04 Euro/100kg		1000 t
France	16.63	21.08	12586.78	8.95	12.83	16377.98
Greece	27.06	34.91	1566.00	14.82	20.88	2210.00
Italy	22.30	26.85	8454.20	13.92	18.74	11375.06
Portugal	21.76	40.34	766.00	12.82	23.22	795.19
Spain	23.09	27.54	2590.41	13.58	18.03	4765.90
EU	18.87	24.26	9688.31	11.17	15.77	42283.83

Source: Eurostat – New Cronos Database – Agris table

Table 3: Hurdle rates for grain maize.

Country	Hurdle rate 1973-1995	Hurdle rate 1973-2004
France	1.48	1.35
Greece	1.09	1.31
Italy	1.25	1.29
Portugal	1.12	1.16
Spain	2.67	1.56
EU	1.17	1.11

Source: own computations based on Eurostat – NewCronos Database.

Table 4. Scenario 1 - Hurdle rates, annual social incremental reversible net benefits (*$SIRB_a$*), social incremental irreversible benefits (*$SIIB_a$*), and maximum incremental social tolerable irreversible costs (*$MISTIC_a$*) per adopted hectare of Bt-maize, per household and per corn growing farmer, year 1995, with price support system for grain maize

Member State	$SIRB_a$ (€/ha)	$SIIB_a$ (€/ha)	$MISTIC_a$ (€/ha)	$MISTIC_a$ (Mio. €)	$MISTIC_a$ (€/household)	$MISTIC_a$ (€/farmer)
France	104.18	1.32	71.71	17.95	0.78	113
Greece	183.79	1.32	169.94	4.17	1.10	43
Italy	149.94	1.32	121.28	17.55	0.86	46
Portugal	344.87	1.32	309.24	8.46	2.56	43
Spain	257.26	1.32	97.67	5.40	0.45	40
EU[a b]	160.52	1.32	138.52	57.48	0.39	66

[a] The hurdle rate is estimated based on the value of the whole EU production.
[b] Per hectare figures for the EU are obtained dividing the sum over the EU-15 member states by the number of adopted hectares in the EU.

Table 5. Scenario 2 - Hurdle rates, annual social incremental reversible net benefits (*$SIRB_a$*), social incremental irreversible benefits (*$SIIB_a$*), and maximum incremental social tolerable irreversible costs (*$MISTIC_a$*) per adopted hectare of Bt-maize, per household and per corn growing farmer, year 2004, with price support system for grain maize

Member State	$SIRB_a$ (€/ha)	$SIIB_a$ (€/ha)	$MISTIC_a$ (€/ha)	$MISTIC_a$ (Mio. €)	$MISTIC_a$ (€/household)	$MISTIC_a$ (€/farmer)
France	78.24	1.09	59.04	16.52	0.67	136
Greece	102.17	1.09	79.08	3.05	0.76	73
Italy	117.45	1.09	92.14	16.93	0.76	68
Portugal	267.25	1.09	231.48	4.81	1.38	38
Spain	265.73	1.09	171.43	12.72	0.93	138
EU[a b]	145.13	1.09	131.83	61.10	0.39	104

[a] The hurdle rate is estimated based on the value of the whole EU production.
[b] Per hectare figures for the EU are obtained dividing the sum over the EU-15 member states by the number of adopted hectares in the EU.

Table 6. Scenario 3 - Hurdle rates, annual social incremental reversible net benefits (*$SIRB_a$*), social incremental irreversible benefits (*$SIIB_a$*), and maximum incremental social tolerable irreversible costs (*$MISTIC_a$*) per adopted hectare of Bt-maize, per household and per corn growing farmer, year 2004, without price support system for grain maize

Member State	$SIRB_a$ (€/ha)	$SIIB_a$ (€/ha)	$MISTIC_a$ (€/ha)	$MISTIC_a$ (Mio. €)	$MISTIC_a$ (€/household)	$MISTIC_a$ (€/farmer)
France	44.29	1.09	33.90	9.48	0.38	78
Greece	61.73	1.09	48.21	1.86	0.46	19
Italy	72.87	1.09	57.58	10.58	0.48	43
Portugal	69.60	1.09	61.09	1.27	0.36	10
Spain	123.88	1.09	80.50	5.97	0.44	65
EU[a b]	77.82	1.09	71.20	34.28	0.22	58

[a] The hurdle rate is estimated based on the value of the whole EU production.
[b] Per hectare figures for the EU are obtained dividing the sum over the EU-15 member states by the number of adopted hectares in the EU.

Scope / Reversibility	Private	External (Public)
Reversible	**1** Reversible Benefits (*PRB*) Reversible Costs (*PRC*)	**2** Reversible Benefits (*ERB*) Reversible Costs (*ERC*)
Irreversible	**3** Irreversible Benefits (*PIB*) Irreversible Costs (*PIC*)	**4** Irreversible Benefits (*EIB*) Irreversible Costs (*EIC*)

Figure 1: The two dimensions of an ex ante analysis of social benefits and costs of transgenic crops (adopted from Demont et al. 2005).