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THE BARROSO PROPOSAL OF NATIONALIZING GM APPROVAL: A LOOK AT HT SUGAR BEETS UNDER CHANGED EUROPEAN SUGAR POLICY

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Abstract

The president of the European Commission José Manuel Barroso proposed in 2009 to nationalize the approval of genetically modified crops. We use a stochastic partial equilibrium model with irreversibility to analyze the effect of the Common Market Reform for sugar on the maximum incremental social tolerable irreversible costs (MISTICs) of genetically modified herbicide tolerant sugar beet. Voting for approval based on the MISTICs is assessed at the national and the EU level. Results show that the Barroso proposal is more proportional to the economic incentives of technology than the different EU treaties.

Keywords: agriculture policy, Bayesian decision analysis, biotechnology, MISTICs, technical change

Introduction

Despite the first commercial introduction of genetically modified (GM) crops almost 15 years ago, the discussion on their benefits and risks is still at the forefront of the debate in the European Union (EU). Over the years, the focus of the debate has shifted over diverse frames of reference as freedom of research, environmental risk, food safety, consumer protection, bioethics, economic policy and international trade (Scholderer, 2005). Since the end of the *de facto moratorium* in 2004, harmonized EU regulations are in place for deregulation for cultivation and imports, and for labeling and tracing. Despite this harmonization, only two GM crops are deregulated for cultivation and only one Bt maize variety is commercialized, with adoption limited to eight EU Member States (Devos et al., 2009).

Two major regulatory reasons for this standstill can be determined. First, several Member States use a safeguard clause to ban GM crop production on their territory, based on their perception that novel concerns on consumer safety and environmental risk exist (Protection, 2009; Sheingate, 2009). Secondly, the EU struggles with the implementation of coherent national regulations to ensure the coexistence of GM and non-GM production systems (Beckmann, Soregaroli, & Wesseler, 2010; Demont et al., 2009; Devos et al., 2009). Moreover, it has been suggested that national authorities exploit their authority on coexistence regulations to design measures that hamper cultivation on their territory (Devos, Demont, & Sanvido, 2008).

In his visionary talk at the end of his first term as the president of the European Commision, José Manuel Barroso suggested a solution for this stalemate, "… it should be possible to combine a Community authorization system, based on science, with freedom for Member States to decide whether or not they wish to cultivate GM crops on their territory" (Barroso, 2009). The idea, first proposed by Austria at the Council of Environment Ministers in Luxembourg in June 2009, would confer the decision of GM deregulation to the subsidiarity principle and allow the individual Member States some degree of sovereignty in the field. The Barroso proposal would converge the authority on deregulation with the authority on cultivation practices under the coexistence regulations. Consequently, decision making can be determined solely at the national level instead of the supranationalism or the intergovernmentalism level, potentially increasing regulatory efficiency

(Lieberman, 2006). Although the implementation of the Barroso proposal has to be verified against the regulation of internal markets as specified in the Lisbon Treaty and the signed WTO treaties, it has the potential to end the standstill in the deregulation of new GM crops and their cultivation, as it is backed by a substantial amount of Member States (GMO safety, 2009).

In this study, we assess how the Barroso Proposal could affect the deregulation of herbicide tolerant (HT) sugar beet in the EU. This is done through a comparison of the proposal with the EU Treaty it would replace. For such a comparison the driving forces behind the political process have to be understood. The established literature on the decision making and voting behavior in the EU has highlighted different determinants in the position of a Member State towards GM crop cultivation, including the dominance of small scale farming, the presence of a strong biotechnology sector and the share of organic production (e.g. Cooper, 2009; Kurzer & Cooper, 2007b). In this paper, the assumption is made that the decision is made based on economic rationale, i.e. the EU tries to maximize the welfare of EU citizens. However irreversible effects and uncertainty surround the introduction of GM crops and influence the political outcome (e.g. the safeguard clause, precautionary principle) (Wesseler, Scatasta, & Nillesen, 2007). Hence these concepts need to be explicitly incorporated in the political economic framework. A Bayesian decision analysis, i.e. real options, does this by estimating the maximum incremental social tolerable irreversible costs (MISTICs) that justify the immediate release of the technology (Ansink & Wesseler, 2009; Batie, 2003; Demont, Wesseler, & Tollens, 2004; Gollier & Treich, 2003; Hennessy & Moschini, 2006; Mooney & Klein, 1999; Morel et al., 2003; Wesseler, Scatasta, & Nillesen, 2007). In his dissertation, Demont (2006) takes a similar approach. However, his setup assumes that the EU functions as a single decision maker weighing (with different weights depending on the scenario) the benefits and risk of individual Member States in order to reach a societal optimal outcome. in reality, the decision at the EU level is reached through a political process in which representatives support national stands on the introduction. Hence, in this paper we take one step back and start from the voting behavior of individual citizens and follow their vote through the regulatory process. The underlying assumption is that the magnitude of a citizen's

MISTIC determines the individual voting behavior. The higher a voter's MISTIC, the higher his incentive to support the introduction of the technology.

The earlier described stochastic partial equilibrium model EUWABSIM (Dillen, Demont, & Tollens, 2009a; Dillen, Demont, & Tollens, 2008) provides the necessary data for the Bayesian analysis. Demont et al. (2004) apply a real options approach on the same model but without the inclusion of the changes described in Dillen et al. (2009a; 2008) . Moreover in this paper, the model output is used to calibrate the assumed stochastic process, which assures a technology specific calibration, different from earlier approaches.

Applying the framework on the case of HT sugar beet deregulation is particulary interesting as two policies affecting the process recently changed. In 2006, the Common Market Organization (CMO) for sugar underwent its first drastic reform since the establishment in 1968 (Dillen, Demont, & Tollens, 2008). Hence, we can estimate the MISTICs under both the old and the new CMO and its differential effect on deregulation. Secondly, in 2009 the EU adopted a new treaty, anticipating the enlargement of the EU, which rewrites the procedures of decision making in the EU. Comparing both treaties allows the assessment of different voting rules within the EU on the likelihood of deregulating HT sugar beet and its relation to the economic incentives.

The paper is structured as follows. In the next section, a comparison is made between the conventional sugar beet production and the potential HT sugar beet system, particularly with regard to the irreversible benefits and costs associated. In the third section, both the Bayesian decision analysis and the stochastic partial equilibrium model, yielding social reversible benefits, are introduced. Special attention is given to the calibration procedure of the stochastic process and the differences with earlier approaches. The fourth section presents the MISTIC values and describes the impact of the CMO reform on these values. The fifth section discusses the individual voting behavior and assesses the likely outcome under the different voting rules considered. The final section discusses and concludes.

Herbicide Tolerant Sugar Beet

Herbicide tolerant sugar beet is very appealing for EU agriculture as it is grown in most EU countries and economic sugar production is impossible without weed control. HT sugar beet allows the farmer to use a single broad-spectrum herbicide instead of mixtures of different active ingredients (a.i.). Hence, it allows easier and more flexible control of weeds within a crop than by conventional herbicides or mechanical means. Switching from conventional sugar beet cultivation to HT sugar beet cultivation implies a shift in production system, not just using a single different input (Alexander & Goodhue, 2002; Dillen, Demont, & Tollens, 2009a). This change in production system has different agronomic and economic consequences. In this section we focus on the quantifiable social irreversible costs and benefits accompanying the change in production system based on, Bückmann et al. (2000) and Schäufele (2000) (displayed in Table 1).

The conventional herbicide mix is replaced by the application of a broad spectrum herbicide, hence both the type of a.i. and the amount of a.i applied per hectare is altered. Similar to Demont et al. (2004) we estimate the external cost of releasing a.i. in the environment based on Pretty et al. (2001). Accounting for the annual human health cost and the loss of biodiversity, each kilogram of a.i. released in the environment has an external cost to society of €1.13.[1] The monetarization by Pretty et al. (2001) does not account for the difference in toxicity level of a.i.. For instance for HT maize, Devos et al. (2008) show that, due to the lower acute toxicity of broad-spectrum herbicides and the lower potential to contaminate ground water, the pesticide occupational and environmental risk (POCER) indicator was reduced significantly under the HT regime. Therefore the aforementioned value can be considered as a conservative estimation. Interestingly Table 12 indicates that in some countries the shift to HT sugar beet would increase the amount of a.i. released. This is in contrast with some earlier studies (e.g. Coyette et al., 2002) predicting a decrease in a.i. following the introduction of HT sugar beet. This can be explained by a recent reduction of the number of a.i. in conventional sugar beets

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[1] Pretty et al. (2001) consider USA, Germany and the UK. We extrapolate the results for the UK to the rest of Europe. All monetary data were discounted to 2006 using the World Development Report Indicators published by The Worldbank (www.worldbank.org)

(Eurostat, 2007). According to industry sources, this is a result of a tendency to increased efficiency in conventional cultivation in view of a revision of the EU regulations on herbicide application.

The HT production system also alters the number of herbicide applications as described in Table 1. Diesel use per application per hectare is estimated by Rasmusson (1998) at 1.43l/ha which translates to 3.56kg CO_2/ha following Phipps and Park (2002). Using the price for CO_2 estimated by the Intergovernmental Panel on Climate Change (IPCC, 2001) the monetary value can be calculated.

Finally, farmers may be more inclined to adopt reduced or zero tillage systems as the control of perennial grass weeds comes at no extra cost under a broad-spectrum herbicide (May, 2003). Results from the adoption of HT canola in Canada show a strong correlation with the adoption of reduced tillage. Similar results have been reported for the adoption of HT soybeans in the United States (Kalaitzandonakes, 2003). The adoption of reduced or zero tillage systems provides a number of environmental benefits. This includes an increase in biodiversity and reduced nutrient run-off. Carbon sequestration has also been mentioned but still remains controversial (Baker et al., 2007). The IPCC recommends to use a 10% increase in soil carbon sequestration for a change from conventional tillage to zero tillage and a 5% increase for a change from conventional tillage to reduced tillage in temperate climates (West & Post, 2002). The effect of adoption of reduced tillage systems induced by HT sugar beets remains questionable. Romaneckas et al. (2009) report no yield effect of a shift from conventional to reduced tillage for Lithuania while Koch et al. (2009) report a yield decrease for Germany. Given the controversy assessing soil carbon sequestration and the possibility of a negative yield effects on sugar beets we do not consider potential benefits of reduced or zero tillage adoption with the introduction of HT sugar beets, but note that this may result in an underrepresentation of irreversible environmental benefits.

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The Economic Model

The introduction of a novel technology is surrounded by uncertain benefits and costs, both affecting private stakeholders and society as a whole. The decision maker has to decide whether to release the technology immediately, or wait until further information becomes available. In the context of *ex ante* impact assessments, different methodologies are developed to account for a part of these uncertainties (e.g. Demont et al., 2008; Dillen, Mitchell, & Tollens, 2010). However, these methodologies do not take into account the presence of irreversible and time effects. In the context of HT sugar beet, these could include e.g. pollen drift, health issues, herbicide resistance or effects on biodiversity. The Bayesian decision analysis of real options, suggested by Morel et al. (2003) in the context of GM crops, offers a tool to account for these irreversible effects. Some papers have followed this approach to increase the understanding of the socio-economic impact of the potential introduction of GM crops (e.g. Demont, Wesseler, & Tollens, 2004; Wesseler, Scatasta, & Nillesen, 2007).

In order to optimize the welfare of EU citizens, the decision making unit has to weigh the expected social reversible net benefits against the social irreversible net costs. Through the explicit inclusion of the possibility of postponing the introduction hysteresis is introduced. The technology should only be released if the reversible net benefits are greater than the irreversible net costs multiplied by a factor higher than one, the *hurdle rate*. The real option approach does allow the quantification of this the hurdle rate, h, through contingent claim analysis and standard real option pricing models (Demont, Wesseler, & Tollens, 2004; Dixit & Pindyck, 1994).

$$h = \frac{\beta}{\beta - 1} \qquad (1)$$

with

$$\beta = \frac{1}{2} - \frac{r-\delta}{\sigma^2} + \sqrt{\left(\frac{r-\delta}{\sigma^2} - \frac{1}{2}\right) + \frac{2r}{\sigma^2}} > 1 \qquad (2)$$

where r is the riskless rate of return, δ the convenience yield and σ the drift rate of a geometric Brownian motion.

The full extent of the social irreversible costs and benefits of GM crops are highly uncertain and central in the precautionary principle followed by the EU. However, the net social reversible benefits can be determined through the EUWABSIM model. Hence, reformulating the aforementioned decision criteria, the maximum incremental social tolerable irreversible costs, MISTICs, can be calculated, justifying the immediate release of the technology,

$$I^* = R + W/h \quad (3)$$

where R represents the quantifiable social irreversible benefits and costs and W the social reversible benefits. The threshold value I^* defines a space where immediate introduction of the GM crop would be rational.

Social reversible effects

To assess the social reversible benefits of HT sugar beet, an adapted version of the EUWABSIM model is used. The model, described in earlier papers is a stochastic partial equilibrium model calculating the technology induced worldwide welfare effects of a hypothetical introduction of HT sugar beet. Starting from a corporate profit maximizing framework with heterogeneous adopters, developed by Dillen et al. (2009), it simulates the introduction of a technology protected by intellectual property rights in an open economy (Alston, Norton, & Pardey, 1995; Moschini & Lapan, 1997). 19 regions are included, each of them modeled by a non linear constant elasticity supply function: 17 EU regions[2], the rest of the world sugar beet region and a sugar cane region. These differentiated supply functions are aggregated into an EU and ROW supply function. This specification allows for heterogeneity among Member States and for technology spillovers in the ROW beet region. The social reversible benefits are calculated as welfare changes, both consumer and producer surpluses (Demont, 2006). Both the old and the new CMO are explicitly modeled for the time span of 2006-2014, to incorporate the policy specific price and supply effects. The main differences lie in the decreased institutional price for sugar and the reduced export possibilities for the EU. This translates in a diminished production under the new CMO, shifting production to low cost producers (Bogetoft et al., 2007; Buysse et al., 2007; Gohin & Bureau, 2006). Dillen et al. (2008) show that, as a secondary effect, the incentive to adopt HT sugar beet decreases significantly for the high cost producers, stimulating the crowding out effect of these producers in time.

[2] The remaining EU member states either do not produce sugar beets or very low amounts. Our 17 regions represent 92% of the EU's sugar production (Eurostat, 2009). Results are only presented for 16 EU regions as Ireland abolished sugar beet production under the new CMO, making a comparison impossible.

The technology adoption process follows a logistic pattern following Griliches (1957) as described in (Dillen, Demont, & Tollens, 2009b). The long term adoption ceilings, $\rho_{max,i}$, are extracted from the study by Dillen et al. (2009a) that estimates these ceilings based on a uniform European wide technology premium of €95/ha. The other parameters in the adoption function are calibrated on the diffusion of HT soybean in the USA (Dillen et al. 2009b). This innovation relies on the same technology and reaches adoption rates similar to $\rho_{max,i}$ (NASS, 2009). Producer surpluses are calculated as the region annual welfare per hectare multiplied with the adopted acreage, which forces the welfare function ($W_{i,c}(t)$) to follow a similar logistic pattern.

$$W_{i,c}(t) = \frac{W_{max,i,c}}{1+\exp(-a_W - b_W t)} \tag{1}$$

where a_W and b_W are a constant of integration and the diffusion rate respectively that are assume constant for the different Member States, t is time, i differentiates the Member States and c is a dummy variable specifying the old or the new CMO. $W_{max,i,c}$ is the highest annual welfare effect during the time period considered from 2006 to 2014. The 2006 net present value of the social reversible benefits can be calculated as

$$W_{06,c} = \int_0^{\infty} W_{i,c}(t)\, exp^{-\mu t}\, dt \tag{2}$$

where μ is the risk-adjusted rate of return derived from the capital asset pricing model.[3] Hence, our results refer to the year 2006, the year in which we assume the start of adoption and when the CMO reform for sugar took place.

Social irreversible effects

The known social irreversible effects, r_i, of the HT sugar beet innovation were described in section 2 and presented in Table 12. They are approximated by,

$$r_i = \sum(A_i, N_i) \tag{3}$$

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[3] Following Demont et al. (2004) and Wesseler et al. (2007) we set μ at 10.5%.

with A_i the social effect of a reduced number of a.i. and, N_i the social irreversible benefit of reduced carbon dioxide. We assume that r_i is not affected by the change in CMO.[4] Assuming that the per hectare social irreversible benefits and costs are proportional to the adoption function, the 2006 present value, $R_{06,i}$ can be calculated by

$$R_{06,i} = \int_0^\infty R_i(t) exp^{-\mu t} dt \qquad (4)$$

where $R_i(t) = r_i \frac{\rho_{max,i}}{1+\exp(-a_W - b_W t)}$.

Calibration of the MISTICs

To calculate the hurdle rate, *h*, some additional calibration parameters are needed. As a solution to the real options was reached through contingent claim analysis, a risk-free rate of return has to be decided. Following earlier papers on GM crops we set *r* at 4.5% to complement the risk adjusted rate, μ, of 10.5% (Demont, Wesseler, & Tollens, 2004; Wesseler, Scatasta, & Nillesen, 2007).

Central to the real options approach is the stochastic process followed by the value of the technology. The standard assumption is that the time series of technology pay-offs follows a geometric Brownian motion (Dixit & Pindyck, 1994). Different approaches haven been used in the literature to determine the drift rate, α, and the variance, σ, of the Brownian motion. Previous studies calculated hurdle rates using time series data based on past performance of economic variables such as prices, revenues or gross margins (Demont, Wesseler, & Tollens, 2004; Pietola & Wang, 2000; Rahim, van Ierland, & Wesseler, 2007; Wesseler, Scatasta, & Nillesen, 2007), while other studies use simulation results projecting returns of a technology (Ndeffo Mbah et al., 2010; Purvis et al., 1995; Winter-Nelson & Amegbeto, 1998) or investments (Hinrichs, Musshoff, & Odening, 2008; Musshoff & Hirschauer, 2008; Odening, Musshoff, & Balman, 2005). In this study we calculate the maximum likelihood estimators for α and σ using the results of the EUWABSIM model. $W_{i,j,c}$ is the net welfare effect of the technology per adopted hectare in country *i*, in year *j* under policy *c* given the logistic adoption pattern. The EUWABSIM output can be transformed into a differential time series for the period

[4] This is a simplification. As the reform of the CMO reduced production in the EU and crowed out a group of farmers, the average cultivation properties may have changed. However, data to assess this change in practices is not available at this time.

2006-2014. This data output represents the technology specific growth under the policy's and the technology's particularities and can be used to estimate α and σ, needed to calculate β and the hurdle rate, [5]

$$\sigma = stddev\left[\ln\frac{W_{i,j,c}}{W_{i,j-1,c}}\right] \tag{5}$$

$$\alpha = mean\left[\ln\frac{W_{i,j,c}}{W_{i,j-1,c}}\right]. \tag{6}$$

However, as the EUWABSIM model has a stochastic nature, this differential time series is not deterministic due to uncertain effects and inputs. Table 11 presented the stochastic variables influencing the outcome of the EUWABSIM model such as yield boost and elasticities. How these are transposed to the technology pay-off depends on the applied sugar price system and the volume traded on the world market. Therefore, the parameters and the hurdle rate, *h*, are calculated for each single iteration of the Monte Carlo simulation representing a certain possible time series of the technology. Aggregating the simulation results leads to a stochastic hurdle rate instead of a deterministic value in earlier studies. The hurdle rate's simulated distribution is approximated by a triangular probability density function to incorporate this stochastic nature in the calculation of the MISTICs.[6]

Model Results

Table 13 presents the results of the modeling exercise i.e. $\rho_{max,i}$, $W_{max,i}$, the mean hurdle rate and the values of *W*, *R* and *I** as annuities (subscript a). W_a are the highest in Spain, the Netherlands, Austria and Portugal under both the old and the new CMO. For some countries W_a decreases under the policy reform while for others the value increases. For, a detailed discussion on the effect of the policy change on the welfare creation, the reader is referred to Dillen et al. (2008) as several factors play a key role; the changing price structure, the old quota structure and changes through time. $\rho_{max,I}$ ranges from 43% in Greece and Italy to 99% in Portugal. The range can be explained through the use of a

[5] There is no reason the technology pay-off would not follow a geometric Brownian motion. Seasonality plays no role as annual averages are used for the calibration nor does time dependency. The assumption of lognormality does not cause problems as long as adopters can temporarily replace HT sugar beet with conventional without additional costs. For HT sugar beet this assumption seems not problematic.

[6] As no theoretical correct distribution for this rate is known, a triangular PDF was chosen for transparency of the model.

uniform technology fee while herbicide expenditures are not uniform among Member States. Hence, countries with previously high herbicide costs or low heterogeneity among farmers tend to have higher adoption ceilings. The social irreversible net effects vary among countries but are generally small ranging from €-0.36/ha to €5.10/ha.

The hurdle rates differ significantly between the old and the new CMO. Under the new CMO, where the export sugar is limited and there is limited effect of world market prices on domestic sugar prices, the variation though time, and hence the drift of the Brownian motion, is very low, leading to hurdle rates close to 1. If we look very closely we can see that world price responsive countries (i.e. Austria, Belgium, Germany, France, UK) have the highest hurdle rates as they are marginally exposed to price changes on the world market. Under the old CMO hurdle rates are generally higher. The reason is country specific and is a result of the higher variance in technology pay-off due to different systems of sugar pricing and the volume exported on the volatile world sugar market. A higher hurdle rate under the old CMO indicates that social irreversible costs have to be compensated by a higher amount of social reversible net benefits in order to justify an immediate deregulation of HT sugar beet. However, as W_a also changes, the outcome is not straightforward.[7]

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Under the old CMO the highest annual MISTIC values are found in Portugal (€254/ha) and Spain (€169/ha) and the lowest in Germany (€14/ha) and Denmark (€21/ha). This is a combined effect of the fact that high cost producers have a higher share of production under the A-quota, and thus benefit from higher sugar prices, and the higher hurdle rate of sugar exporting countries. The total annual MISTICs within a Member State these amount to €19 million and €15 million in Poland and France respectively. This is mainly driven through the magnitude of adopted hectares in these countries. Spain also has a high MISTIC value driven by the high potential adoption rate and high benefits per hectare.

[7] The hurdle rates for the old CMO for sugar differ significantly from Demont et al. (2004) and are generally lower. By calibrating the Brownian motion on a time series of gross margins several factors, Demont et al. introduce sources of variability, e.g. weather effects, world market prices and other technologies in sugar beet production, that do not directly relate to the technology of HT sugar beet leading to higher hurdle rates.

Portugal, despite high W_a values and high adoption, has low MISTICs due to the negative value of R_a and low acreage.

Under the assumption that the negative externalities from HT sugar beet introduction stay at the sugar beet farm, we can assess the MISTIC farmers are willing to accept to justify a release of the technology. Portugal and Czech Republic have present the highest MISTIC at the level of the sugar beet holding. For Portugal the reason can be found in the high value per adopted hectare combined with the high adoption. The high value in Czech can be explained by the size of typical sugar beet farms in the country. The lowest MISTICs can be found in Germany with €131/farm.

Under the new CMO, the MISTICs range from €48,1/ha in Italy to €197.6/ha in Portugal. This range is smaller due to the smaller value of α and thus hurdle rate. Comparing the individual outcomes under both regimes reveals that the new MISTICs are higher for all countries except Greece, Italy, Finland and Portugal. As these countries are generally considered high cost sugar producers, the conclusion can be drawn that competitive countries have a higher incentive to adopt the technology under the new CMO through increased W_a and lower hurdle rates. At the national level the MISTICS are high in Germany and France but low for Portugal and Finland. At the farm level Czech has by far the highest MISTIC with €3838/ha followed by Denmark, Germany and France, a group of competitive sugar producers. These farm level values indicate that if the decision was left to them whether or not to introduce the technology, they would allow a significant amount of irreversible costs as the value created by the technology is large.

Voting Assessment

Following Directive 2001/18/EC of the EU, the decision whether or not to release a GM crop for commercial use typically begins at the level of the national competent authorities.[8] They notify the EU and the European Food Safety authority starts with the preparation of a scientific risk assessment. Based on this opinion, the European Commission (EC) formulates a draft decision and presents this to the regulatory committee, a group of Member State experts. Within this group a *qualified majority* is

[8] The website http://www.gmo-compass.org provides an overview about the steps for gaining approval for planting GM crops in the EU.

needed to reach consensus and for the Commission to adopt the regulation. If no qualified majority is reached, the EC's draft is forwarded to the Consilium, better known as the Council of Ministers. Here, a qualified majority is again needed to adopt the regulation. If no decision is reached within three months, the Commission itself may deregulate the GM crop for EU-wide use (Sheingate, 2009). Kurzer et al. (2007a) argue that agricultural biotechnology is one of the rare occasions where consumers have overruled the EU's policymaking process. Through their organized action, consumer movements have transformed a pro-GM approval system to a market situation where GM food is labeled and its availability low. This study follows another approach and assumes that consumers solely influence the EU decision making through their voting behavior. Moreover, the assumption is made that the individual's MISTIC value determines the tendency to vote for or against approval of a GM crop. If an individual has a high MISTIC value, he/she is more inclined to vote for approval. $I^*_{vote,c}$, the MISTIC per voter per year from HT sugar beet under policy c, is calculated by dividing I_a^* through the number of people older than 18 (Eurostat, 2009) and shown in Table 14. The individual voting behavior can be represented by

$$V_{Ind} = \begin{cases} 1 \ if \ I < I^*_{vote,c} \\ 0 \ otherwise \end{cases} \tag{7}$$

where I is the actual incremental social tolerable irreversible costs. Although I cannot be determined, it is clear that if $I^{*1}_{vote} < I^{*2}_{vote}$ than $P(V_{ind}=1 | I^{*1}_{vote}) < P(V_{ind}=1 | I^{*2}_{vote})$. Under the assumption that all citizens have a similar exposure to irreversible social net costs, $I^*_{vote,c}$ is uniformily distributed within each Member State. Therefore, V_{ind} directly translates to a decision at the national level and consequently the decision of their representatives in the Council of Ministers.

At the Council of Ministers, a qualified majority is essential to proceed with the deregulation of GM crops in Europe. The criteria to reach a qualified majority are described in the EU's treaty. The aim of a qualified majority is to introduce a correction for the differences population between Member States in the voting procedure. The voting weights are presented in Table 14. Under the Nice Treaty, which entered into force on 1 February 2003, a qualified majority is reached if the countries pro regulation represent more than half of the Members States and 74% of the voting weights and 62% of the EU population (Felsenthal, 2001). Hence, V_{QMnic}, has the following form:

$$V_{QMnic} = \begin{cases} 1 \; if \; \sum_{j \epsilon N} v_j \geq 0.74 \sum_N v_n \wedge j \geq 0.5n \wedge \sum_{j \epsilon N} p_j \geq 0.62 \sum_N p_n \\ 0 \; otherwise \end{cases} \tag{8}$$

with N the set of n Member States, j the countries voting in favor of the proposal, v the weights assigned in the voting process to each Member State according to the Nice treaty and p the population within country j or n.

On 1 December 2009, the Lisbon Treaty replaced the Nice treaty. The Lisbon Treaty includes, among other things ensuring efficient governance in an expanding EU, new criteria to reach a qualified majority. However, in a transitional phase until 31 October 2014 the voting rules of the Nice Treaty stay in place. From 2014 on, the criteria to pass are a positive vote by a majority of countries (55%) representing 65% of the population or every situation where the criteria to block are not met. To block a proposal, at least 4 Member States have to vote against the proposal or in cases where not all members participate, the minimum number of members representing more than 35% of the population of the participating Member States, plus one member,

$$V_{QMlis} = \begin{cases} 0 \; if \; \# k = 4 \; \wedge \; \sum_{k \epsilon N} p_k \geq 0.35 \sum_N p_n \\ or \; if \; \sum_{k \epsilon N} p_k \leq 0.35 \sum_N p_n : the \; \# \; of \; countries \; to \; (\sum_{k \epsilon N} p_k \geq 0.35 \sum_N p_n) + 1 \\ \\ 1 \; if \; j \geq 0.55n \wedge \sum_{j \epsilon N} p_j \geq 0.65 \sum_N p_n \; and \; all \; remaining \; situations \end{cases}$$

with k the countries voting against the proposal (European Union, 2007).

The proposal introduced by Barroso at the end of 2009 has the aim to circumvent the rules of the qualified majority by shifting the authority on deregulation to the national level. Consequently in our model the decision whether or not to allow cultivation of GM crops on their territory is transformed to an autonomous dichotomous process directly reflecting the individual voting behavior within the Member State. Hence, the outcome under the Barroso proposal can be represented by,

$$V_{Bar,i} = V_{ind} = \begin{cases} 1 \; if \; I < I^{*}_{vote,i,c} \\ 0 \; otherwise \end{cases}. \quad (10)$$

With the voting rules laid out, the results from Table 14 can be used transfer the individual vote decision to a EU deregulation. Each value of $I*_{vote,c}$ can be considered as a threshold value for a positive vote in a particular country following equation 7. In order to evaluate the set of equations 8-10 we start with the Member State with the highest $I*_{vote,c}$ and add the next Member State in the row until a qualified majority is reached. Hence, a threshold for *I* can be determined which would justify the immediate release of the technology under the differ. To allow for the fact that not all Member States are present in our analysis, the relative shares were used representing the situation that only these countries would have voting rights on the approval of HT sugar beet.

First consider the situation as present in the EU, the voting rules of the Treaty of Nice combined with the new CMO for sugar. The results show that

$$V_{QMnic,new} \begin{cases} 1 \; if \; I < \frac{€0.19}{voter * year} \\ 0 \; otherwise \end{cases} \quad (11)$$

As long as the irreversible social incremental costs are below €0.19/ voting citizen deregulation will happen. Replacing the Nice Treaty with the Lisbon Treaty results in a higher threshold value,

$$V_{QMlis,new} \begin{cases} 1 \; if \; I < \frac{€0.28}{voter * year} \\ 0 \; otherwise \end{cases} . \quad (12)$$

For the Lisbon Treaty the opportunity to block a proposal at the Council of Ministers was also explored in a similar way. However, the requirement to block would only be reached for *I* equal to €0.37 making this an impossibility given the fact that a qualified majority would be reached at €0.28. Similar to previously, we assume that $I^{*1} < I^{*2}$ means that $P(V=1| I^{*1}) < P(V=1| I^{*2})$ or a higher threshold means a higher likelihood of deregulation. Comparing $V_{QMnic,new}$ and $V_{QMlis,new}$ shows that the introduction of the Lisbon Treaty would increase the likelihood of deregulation significantly due to a 47% increase in the threshold value. This is in line with the aim of the Lisbon Treaty to facilitate decision making in a larger EU and reach a consensus more easily.

The same reasoning and sequence of equations can be followed for the old CMO yielding the following result,

$$V_{QMnic,old} = V_{QMlis,old} \begin{cases} 1 \; if \; I < \frac{€0.20}{voter * year} \\ 0 \; otherwise \end{cases} \quad (13)$$

This result suggests that the under the old CMO for sugar the change of treaties does not affect the likelihood of deregulating HT sugar beet.

---TABLE 3 SOMEWHERE HERE---------------------------------

These results lead to an important conclusionn. From a Dillen et al. (2008) we know that the new CMO disfavors the adoption of HT sugar beet for high cost producers. Moreover the results in Table 13 show a higher value of I^*_a is higher for lows cost producers under the new CMO. Hence, the incentives for deregulation in low cost producers have increased under the new CMO. Nevertheless, the results show that $I_{QMnic,new} < I_{QMnic,old}$ indicating that the likelihood for deregulation is lower if voted under the Nice Treaty. However, under the Lisbon Treaty, $I_{QMlis,new} > I_{QMlis,old}$ translating in an increased likelihood of deregulation coinciding with the economic incentives. This confirms the analysis by Leech (2002) that the rules to reach a qualified majority can be too stringent to be an (economic) effective decision making rule.

Let us now turn towards a situation in which I is marginally higher than the highest threshold to reach deregulation under any of the four scenarios. Applying the rules of the Barroso proposal, equation 10, results in the fact that all countries for which $I^*_{vote,c}$ > €0.29 would deregulate while neither under the Nice Treaty nor under the Lisbon Treaty deregulation would take place. Comparing the threshold value of €0.29 with the results in Table 14 highlights the countries that would deregulate HT sugar beet under the Barroso proposal. Under the old CMO all Member States except Denmark, Germany, Italy, Portugal and the United Kingdom would deregulate the cultivation of HT sugar beet on their territory. Under the new CMO, all countries except Greece, Italy, Portugal, the United Kingdom and Hungary would deregulate. Hence, the shift to the new sugar policy would increase the chance of deregulation in two competitive sugar beet countries, Germany and Denmark, while a high cost producer as Greece now has a lower chance of deregulating. Overall, the more competitive Member States have a higher voting threshold under the new CMO, increasing the potential of deregulation under the Barroso proposal. Hence, the Barroso proposal, as expected, provides a better response to the invididual incentives of the Member States and the effects of the sugar policy reform.

Finally, when the absolute values of $I^*_{vote,c}$ are considered, it seems a rational decision by the EU not to engage in an immediate release of HT sugar beet. Despite the high potential value of the technology for sugar beet farmers (Dillen et al. 2009b), and their resulting high MISTICs (Table 13), $I^*_{vote,c}$ values are very low. As long as individuals are prepared to pay as little as €0.08 for German citizens under the old CMO, or €1.32 for Belgian citizens under the new CMO, it is better to postpone the introduction of HT sugar beet. These results are in the same magnitude as the analysis by Demont et al. (2004).

Discussion

This paper presents a Bayesian decision analysis of the introduction of herbicide tolerant sugar beet in the EU. The model is built on a stochastic partial equilibrium model complemented with a real options approach calibrated on the same partial equilibrium model. The aim of the model is twofold. First, the effect of a change in the Common Market Organization for sugar on the MISTICs that justify immediate release of the technology is assessed. Secondly, the decision making process at the EU level is evaluated based on these calculated MISTIC values. In particular the effect of the Barroso proposal compared to the conventional European treaties is estimated.

The results show that the MISTIC value per hectare under the new CMO increases for all Member States except for some high cost producers, Finland, Greece and Portugal. This observation is a combined effect of the change in value added per hectare through the adoption of HT sugar beet, as presented earlier in Dillen et al. (2008) and the effect on the *hurdle rate*. The new CMO, through reduced export opportunities and changed price effects makes the return from the technology more predictable, hence decreasing the uncertainty and the hurdle rate, resulting in increased MISTICs. From a regulators point of view this means that deregulating HT sugar beet under the new CMO would be justified under higher irreversible social costs, hence increasing the economic incentive for approval.

Under the assumption that voters base their position towards GM crops on the magnitude of their personal MISTIC value, the outcomes of different EU decision making protocols are assessed. The results show that increased economic rationale of adopting HT sugar beet under the new CMO is only transformed in a higher chance of deregulation under the Lisbon Treaty while the Nice Treaty even slightly decreases the chance. The Barroso proposal to nationalize deregulation decisions has the closest link to Member States' economic incentives and hence the individual voter. Under irreversible social costs that would never qualify for a qualified majority under the EU treaties, a large majority of the Member States would engage in an immediate release of the technology. Besides the closer link to economic incentives, the Barroso proposal brings the legislative framework of deregulation at the same level as that of coexistence, possibly increasing the efficiency of the resulting decisions and regulations.

Finally, looking at the absolute values of the MISTICs the analysis shows that if citizens are prepared to pay, depending on the Member State and the CMO, between €0.06 and €1.32 annually to avoid the introduction of HT sugar beet, release should be postponed. This result indicates that despite high economic benefits from HT sugar beet and high MISTICs for sugar beet farms the benefits are not enough on a per capita level to justify an immediate release. If the benefits of HT sugar beet would increase in the future through a more liberalized sugar CMO or quality effects for the consumer this could change. These are the same deterministic mechanisms that influence the strength of consumer movements highlighted in the analysis by Kurzer et al. (2007a).

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Table 1: The irreversible benefits and costs as a result from a switch from conventional sugar beet to a HT sugar beet production system

	Dosage of herbicide use 2003 (kga.i./ha)	Glyph. dose (l/ha)	Glyph. dosage (kg a.i./ha)	Difference dosage (kg a.i./ha)	External irreversible herbicide reduction benefits (€/ha)	# Conv. app.	# Glyph. app.	Difference # app.	Diesel use (l/Appl.ha)	Saving in diesel use (l/ha)	Avoided carbon dioxide emission (kg/ha)	External irreversible benefits (€/ha)
Austria	1.6	6	2.16	-0.6	-0.63	2.5	2.5	0.0	1.4	0.0	0.00	-0.63
Belgium	3.0	6	2.16	0.8	0.95	3.5	2.5	1.0	1.4	1.4	4.99	1.44
Denmark	1.8	6	2.16	-0.4	-0.41	4	2.5	1.5	1.4	2.1	7.48	0.34
Finland	2.8	6	2.16	0.6	0.72	3.8	2.5	1.3	1.4	1.8	6.48	1.37
France	3.4	6	2.16	1.2	1.40	3.8	2.5	1.3	1.4	1.8	6.48	2.04
Germany	2.4	6	2.16	0.2	0.27	3	2.5	0.5	1.4	0.7	2.49	0.52
Greece	3.7	3	1.08	2.6	2.95	1.5	1	0.5	1.4	0.7	2.49	3.20
Ireland	0.2	6	2.16	-2.0	-2.21	3	2.5	0.5	1.4	0.7	2.49	-1.96
Italy	1.5	6	2.16	-0.7	-0.74	2.5	2.5	0.0	1.4	0.0	0.00	-0.74
Netherlands	3.6	6	2.16	1.4	1.62	3.5	2.5	1.0	1.4	1.4	4.99	2.12
Portugal	0.1	3	1.08	-1.0	-1.10	3	1	0.1	1.4	0.1	0.35	-0.11
Spain	6.9	3	1.08	5.8	6.55	3	1	0.1	1.4	0.1	0.35	7.55
Sweden	2.1	6	2.16	-0.1	-0.07	2.9	2.5	0.4	1.4	0.6	1.99	0.13
UK	3.1	6	2.16	0.9	1.06	4.6	2.5	2.1	1.4	2.9	10.47	2.10
Czech Republic	3.8	6	2.16	1.6	1.85	3	2.5	0.5	1.4	0.7	2.49	2.10
Hungary	3.8	6	2.16	1.6	1.85	3	2.5	0.5	1.4	0.7	2.49	2.10
Poland	2.8	6	2.16	0.6	0.72	3	2.5	0.5	1.4	0.7	2.49	0.97

Sources: Eurostat (2007), Bückmann et al. (2000),Pretty et al. (2001),Schäufele (2000),Phipps et al. (2002)

Table 2: EUWABSIM results, adoption ceilings (ρ_{max}), mean hurdle rates, annual social reversible benefits (W_a), social irreversible benefits (R_a) and maximum incremental tolerable social irreversible costs (I^*_a) per hectare of HT sugar beet and per sugar beet growing farmer.

Member State	ρ_{max}	W_{max}	W_a (€/ha)	R_a (€/ha)	Hurdle Rate	I_a* (€/ha)	I_a* (€)	Coefficient of variation	I_a*/farm (€)
Old CMO sugar									
Belgium	98%	161	103	0.97	1.077613	97	8 107 383	4.79E-02	605
Denmark	82%	158	102	0.19	4.841197	21.3	857 356	6.76E-01	200
Germany	63%	84	51	0.22	3.836102	13.6	5 346 466	5.85E-01	131
Greece	43%	122	83	0.94	1.05967	79.4	2 933 103	3.82E-02	204
Spain	99%	245	164	5.10	1.000278	169.1	15 088 785	1.83E-04	978
France	78%	104	66	1.09	1.448304	46.5	15 859 971	1.97E-01	530
Italy	43%	97	64	-0.22	1.232448	51.9	9 860 526	1.28E-01	274
Netherland	97%	218	142	1.4	1.363038	105.9	9 283 404	1.75E-01	705
Austria	84%	176	113	-0.36	1.135094	99.6	4 680 685	7.97E-02	522
Portugal	99%	382	254	-0.07	1.000081	253.7	1 698 012	5.27E-05	2534
Finland	97%	182	121	0.91	1.000105	122.1	3 000 929	6.75E-05	1409
Sweden	47%	75	49	0.04	1.047497	47	2 375 252	3.11E-02	673
United Kingdom	59%	91	59	0.85	2.747777	22.2	2 557 346	4.54E-01	337
Czech Republic	91%	135	91	1.3	1.000665	92.6	4 872 339	4.41E-04	4640
Hungary	92%	90	60	1.32	1.000254	61.5	3 003 420	1.65E-04	1206
Poland	85%	123	82	0.56	1.004259	82.4	18 504 185	2.95E-03	229
New CMO sugar									
Belgium	98%	198	132	0.97	1.009099	131.9	11 031 382	3.44E-03	823
Denmark	82%	229	145	0.19	1.001713	144.8	5 076 405	6.40E-04	1186
Germany	63%	124	83	0.22	1.010634	82.2	32 244 302	3.79E-03	789
Greece	43%	105	65	0.94	1.002209	66.2	1 315 412	5.06E-04	91
Spain	99%	292	185	5.10	1.001611	189.7	13 470 372	6.05E-04	874
France	78%	150	102	1.09	1.014367	101.3	34 613 129	4.69E-03	1158
Italy	43%	77	48	-0.22	1.002026	48.1	5 509 687	6.77E-04	153
Netherland	97%	248	155	1.4	1.001956	156.4	10 583 648	7.08E-04	804

Austria	84%	212	141	-0.36	1.008735	139.7	6 572 343	3.62E-03	733
Portugal	99%	309	199	-0.07	1.00111	198.3	506 231	4.26E-04	756
Finland	97%	148	95	0.91	1.001445	96.2	1 617 853	5.80E-04	760
Sweden	47%	115	73	0.04	1.001841	72.8	2 538 996	6.37E-04	719
United Kingdom	59%	114	77	0.85	1.012847	76.6	8 838 270	4.57E-03	1164
Czech Republic	91%	167	106	1.3	1.00217	107.5	4 029 889	7.12E-04	3838
Hungary	92%	105	67	1.32	1.001456	67.9	2 255 003	5.58E-04	906
Poland	85%	152	97	0.56	1.001884	97.2	18 719 120	7.01E-04	231

Table 3: The MISTIC per voting citizen and the voting weights under different EU treaties

Member State	Population over 18 years	I_a*/voting person new CMO, $I^*_{vote,i,new}$ (€/year)	I_a*/voting person old CMO, $I^*_{vote,I,old}$ (€/year)	Voting weight under Nice Treaty	Voting weight under Lisbon Treaty
Belgium	8331936	1.32	0.97	12	11
Denmark	4216893	1.20	0.20	7	5.5
Germany	67725607	0.48	0.08	29	82
Greece	9178742	0.14	0.32	12	11
Spain	36017564	0.37	0.42	27	46
France	49006703	0.71	0.32	29	64
Italy	48608776	0.11	0.20	29	60
The Netherlands	12752453	0.83	0.73	13	17
Austria	6647030	0.99	0.70	10	8.3
Portugal	8567879	0.06	0.20	12	11
Finland	4151882	0.39	0.72	7	5.3
Sweden	7113513	0.36	0.33	10	9.2
United Kingdom	46799543	0.19	0.05	29	62
Czech Republic	8359568	0.48	0.58	12	10
Hungary	8108480	0.28	0.37	12	10
Poland	30293256	0.62	0.61	27	38
Total				**277**	**450.3**

Sources: Eurostat (2009), European Union (2007)