Identifying driving factors for the establishment of cooperative GMO-free zones in Germany

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Abstract. Since the end of the quasi-moratorium on genetically modified organisms (GMO) in the European Union in 2004, the establishment of GMO-free zones has become an EU wide phenomenon. In contrast to other European countries, Germany follows the concept of cooperative GMO-free zones where neighbouring farmers contractually refrain from GMO cultivation. In this article, we address the question which underlying factors could account for the establishment of cooperative GMO-free zones in Germany. Drawing on the existing literature on spatial agglomeration of different farming systems and the establishment of GMO-free zones, we provide the first systematic study on driving factors for the regional formation of GMO-free zones in Germany. The empirical analysis is based on a unique data set at the federal states level for the years 2004 to 2007. We show that infestation rates with the European Corn Borer, imminent Bt maize cultivation in the near vicinity and the number of arriving tourists mainly account for the establishment of cooperative GMO-free zones. This finding is consistent with the view that it is more the overall rejection of agro-biotechnology by broad strata of the population, including stakeholders in tourism and environmental protection, than economic benefits at the farm level which make German regions establish GMO-free zones.

Keywords: Genetically modified organisms (GMO), GMO-free zone, econometric analysis, Germany.

JEL codes: O33, Q15, Q16, R52

1 Introduction

After the end of the quasi-moratorium on GM (genetically modified) crops in Europe in 2004, all European Union (EU) member states have been confronted with imminent cultivation of these crops. Probably fuelled by the ongoing public debate about potential negative side effects of GM plants, such as cross-pollination or admixture of GM material, a remarkable phenomenon of collective action has since emerged in many member states: farmers and citizens declare that large tracts of land in a specifically designated region are supposed to be free of any GM organisms. The formation of such GMO-free zones has been observed in almost every EU member state. By the year 2011, Denmark, the Netherlands and the Czech Republic were the only member states of the EU with no such initiative (GMO-free regions, 2011). But what were the reasons for the widespread creation of these zones? Is it more an abstract rejection of agro biotechnology or is there an economic rationale for farmers or other stakeholders to publicly refrain from cultivating GM crops? Which role plays the regional importance of the target pest of GM crops? Who are the key actors in establishing GMO-free zones? These questions are addressed in the following both theoretically and empirically in the German context of GM crop cultivation and GM-free zones.

As the establishment of GMO-free regions is a rather recent phenomenon, the academic literature analysing it is still in its infancy. Contributions so far have mostly focused on aspects of risk control and reducing the costs of coexistence. Another issue to clarify is who are the key actors in establishing these regions. In two early publications, Schermer (2001) and Schermer and Hoppichler (2004) conceptualize a GMO-free zone as an alternative path of development under scientific uncertainty with a high relevance for ecologically sensitive areas. This concept is mainly linked to the perception that the cultivation of GM crops poses unpredictable risks to human health or the environment which can only be controlled by defining areas of no-contamination. However, not only risk aspects matter when conceptualizing a GMO-free zone. The European Guidelines on Coexistence (CEC, 2003) prescribe the freedom of choice for farmers and consumers to select between the three different agricultural production systems, such as organic, conventional and GM. Spatial agglomeration of production systems, e.g. by establishing a GMO-free zone, can thus be regarded as one possible measure to implement regional coexistence. Beckmann et al. (2006) have developed a model to explain regional agglomeration effects under irreversibility and uncertainty. It shows that the rules linked to GM crop cultivation result in incentives for the

GM farmer to collaborate with his neighbours in order to reduce the costs of ex-ante regulation and ex-post liability, which might result in spatially coherent areas of different production systems. Alternatively, by forming a landscape club with a joint buffer zone, organic farmers could protect themselves from negative externalities of GM crop cultivation nearby and increase the welfare for both organic and GM farmers in this geographic region (Furtan et al. 2007). According to Beckmann and Schleyer (2007), a necessary precondition for the establishment of a cooperative GMO-free zone is the perception of the involved farmers about the benefits of GMO-free production. Benefits from adopting GM crops are perceived as being low, where the ECB is of minor importance and organic farming is widespread. Since cooperation is cost-intensive, additional benefits must arise from the formation of a GMO-free zone which compensates the costs of collective action. The authors assume that these additional benefits from cooperation mainly arise from the reduction of (legal) uncertainty, the avoidance of law suits among neighbouring farmers and marketing advantages of GMO-free products or market disadvantages because of GM crop production.

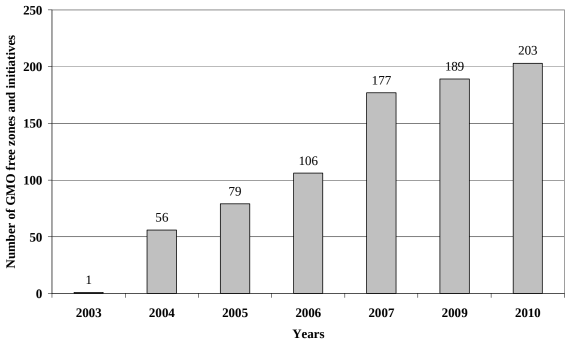
While these theoretical considerations seem plausible, empirical evidence on the factors influencing the establishment of GMO-free zones is scarce. The only study on the determinants of establishing GMO-free zones in Germany so far has been carried out by Nischwitz et al. (2005). They also address the important question of who actually initiates these zones. According to their study, the establishment of GMO-free zones is mainly due to local farmers, for the most part organic farmers. Beyond that, farmers' associations and agricultural producer groups engage in the formation. Bottom-up processes have been proven to be more successful than top-down processes. Expert interviews carried out by the authors revealed that the main reason for the establishment of GMO-free zones was the general rejection of agricultural biotechnology by the involved stakeholders. Moreover, the authors mention factors like safeguarding organic production, avoiding disputes among neighbouring farmers or image benefits for the region. Undoubtedly, GMO-free zones can also be perceived as a response of local actors to an insufficient regulation of GM crop cultivation (Nischwitz et al., 2005, p. 63).

Against this background, the current study is the first to pursue a systematic quantitative analysis of the determinants of establishing GMO-free zones in Germany. After outlining their development and the legal framework for their establishment, we present three groups of factors that are likely to influence the creation of GMO-free zones. These are low opportunity costs for participating farmers, increased benefits from joining a GMO-free zone, and factors reducing the cost of collective action. These factors are then made operational and tested in an econometric model based on a panel data set of German states. The data includes regionally aggregated information about the area under GMO-free zones and various structural and socioeconomic variables for the years 2004 to 2007. We use fixed effects techniques to eliminate unobserved heterogeneity among regions. Our findings suggest that imminent or actual Bt maize cultivation were main drivers of collective action to establish GMO-free zones. Local actors were apparently trying to halt undesired landscape changes by collective action where and when Bt maize area expansion was in the offing. While our findings are consistent with the view that farmers were the ones most interested in establishing GMO-free zones, the variables measuring coexistence costs (such as the presence of organic farms or average farm size) did not turn out to have a significant influence. However, the importance of tourism had a significantly positive effect on GMO-free zone creation, pointing at the importance of GMO freeness for the positive image of a region. This finding implies that the regional economy in general, and its stakeholders, represent an additional important factor in understanding GMO free zones. The fact that the presence of German Friends of the Earth in a given region favours the establishment – although only with weak statistical significance – lends further support to this idea.

The article is structured as follows. In sections two and three, we give an historic overview on the development of GMO-free zones in Germany and the forms of contract which can lead to GMO-free agriculture. We then theoretically derive factors which could account for a cooperative formation of GMO-free zones in the fourth section. In section five we apply an econometric model to test the influence of these factors on the establishment of GMO-free zones in Germany. Section six presents the results, and the final section concludes.

2 History and development of GMO-free zones in Germany

In Germany, the active engagement of 29,836 farmers and other stakeholders has led to the foundation of over 200 cooperative GMO-free zones until the year 2010. According to Nischwitz et al. (2005), a voluntary GMO-free zone is an important measure to ensure GMO-free production and does not contradict current European regulation. In past years, German GMO-free zones showed a high temporal and spatial dynamic. The first GMO-free zone was founded in Mecklenburg-Western Pomerania in 2003. In 2004, the number of GMO-free zones had already increased up to 56, covering 659,653 ha of agricultural land. In the following years, more and more farmers throughout Germany engaged in GMO-free zones (Gentechnikfreie Regionen, 2011). Detailed numbers for the years 2003 to 2010 are displayed in Figure 1 and 2.



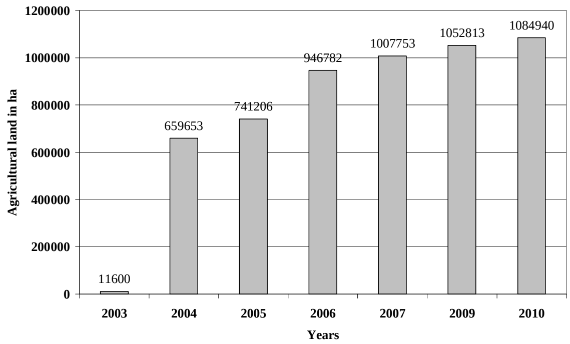


Figure 1 and 2 Number of GMO-free zones and land coverage in ha per year (Source : Gentechnikfreie Regionen, 2011)

Cooperative GMO-free zones are not equally distributed among the German federal states. According to the German platform on GMO-free zones, Bavaria was leading in size and numbers of GMO-free zones with 49 zones covering a total of 501,755 ha agricultural land (average size: 10,240 ha) in 2007, followed by Baden-Wuerttemberg with 27 zones and 139,622 ha (average size: 5,171 ha). Generally low dynamics can be observed from the Eastern and Northern German states. In Brandenburg, five GMO-free zones covered an area of 86,000 ha in 2007 (average size: 17,200 ha), followed by Mecklenburg-Western Pomerania with eight zones and 57,566 ha (average size: 7,196), Saxony-Anhalt with five zones and 28,122 ha (average size: 5,624 ha), Saxony with three zones and 15,580 ha (average size: 5,193 ha) and Thuringia with only one GMO-free zone on 2,400 ha. Schleswig-Holstein and Lower Saxony are also characterized by a moderate development of GMO-free zones: Until 2007, only three zones were founded in Schleswig-Holstein and Lower Saxony, covering an area of 9,000 ha (average size: 3,000 ha) and 1,729 ha (average size: 575 ha). Saarland is the only German federal state where no GMO-free zone has been established so far (Gentechnikfreie Regionen, 2011).

The German platform on GMO-free regions defines a GMO-free zone as “an area where owners, users and cultivators of agricultural land consciously do not make use of genetically modified crops”. In some but not all cases, farmers may also renounce from using GM fodder but there is not a general obligation to do so. One central criterion for a GMO-free zone is its spatial coherence: “a GMO-free zone must consist of a coherent production area” or “at least 2/3 of the agricultural production area of a defined locality, e.g. a municipality, county etc., must be cultivated without using GMO”. Those areas which do not yet fulfil the criteria of a GMO-free zone can call themselves an “initiative to a GMO-free zone” (Gentechnikfreie Regionen, 2011).

3 Legal framework for the establishment of GMO-free zones in the EU and in Germany

In 2003, the European Commission published guideline 2003/556/EC on coexistence of genetically modified crops with conventional and organic farming. According to the recommendation, freedom of choice regarding the different production systems shall be guaranteed to farmers as well as consumers. Cooperation among neighbouring farmers is explicitly mentioned as one tool to guarantee coexistence. Beyond that, “[…] Groups of farmers in a neighbourhood may achieve a significant reduction in the costs related to the segregation of GM and non-GM production types if they coordinate their production on the basis of voluntary agreements […]” (CEC, 2003).

The concept of cooperative GMO-free zones, as practiced in Germany, is also in line with the current EU regulation 2001/18/EC on deliberate release of GMO (EEC, 2001). According to Directive 2001/18/EC, GM crops which hold a positive approval by the European Food Safety Authority (EFSA) must not be generally prohibited at the member states level. The only way to utter a national ban on a certain GM event is to present new scientific evidence which indicate a not yet considered risk of the crop. In this case, the member state can invoke the so called safeguard clause according to Article 23 of Directive 2001/18/EC. This has been done by several countries in the past, such as Austria in 1999, followed by Greece and Hungary in 2006, France in 2007 and Luxemburg and Germany in 2009, although EFSA could not support the member state decision scientifically.

Only recently, the European Parliament facilitated the procedure of national GMO cultivation bans by approving a proposal made by the European Commission. Bans on approved GM crop events are now legally possible for environmental, socio-economic or land use reasons (ISAAA, 2011).

Besides a general ban on GM crop cultivation, GMO-freeness in agricultural production can be governed by different organization forms, which can differ in their contractual design and legal character. All of the below mentioned contract types are present in Germany.

1) Voluntary agreements among farmers:

The governance of GMO-freeness can be based on voluntary agreements among neighbouring farms. This concept is the core element of cooperative GMO-free zones in Germany. Every farmer is free to decide whether to sign a voluntary agreement or not. With this agreement the farmer obligates himself to refrain from the use of GM seeds in agricultural crop production. In some cases, GMO-freeness might also apply to animal feeding, but this is not necessarily prescribed. Generally, the agreements are valid for one year and are prolonged automatically if not otherwise stated. These voluntary agreements range from a single farm to a large coherent area, involving up to several hundred farmers. In this case, actors do not take their decisions individually but collectively. A voluntary agreement for a cooperative GMO-free zone has no legally binding character. This is apparent since it lacks measures of monitoring or sanctioning in case of noncompliance or exit.

2) Contract farming:

GMO-freeness in agricultural production can also be achieved by contract farming, where the use of GM seed or GM fodder is contractually prohibited. In Germany, many food processing companies such as mills and dairies have already obliged their suppliers to produce without GMO. Recently, the large discounter Lidl announced to sell regional dairy products in Bavaria which are GMO-free. Farmers, who produce milk for Lidl have to declare not to use GM fodder (Der Spiegel, 2011). The largest mill in Germany, Kampffmeyer, also prescribes GMO-freeness in their delivery contract (Kampffmeyer, 2010).

3) Tenancy agreements:

In Germany, many landowners have forbidden the use of GM material on their land through tenancy agreements. This is especially true for landowning municipalities and the Protestant Church of Germany (Evangelische Kirche Deutschland). Beyond that, different stakeholder groups have encouraged private landowners to prohibit the cultivation of GM crops on their land (Greenpeace, 2005). A legal opinion launched by Greenpeace Germany in 2008 comes to the conclusion that German law provides room to fix the ban in a tenancy agreement. In the case of tenancy agreements, possible noncompliance with contract conditions can be monitored and sanctioned.

After this short overview on the development of GMO-free zones in Germany and the contractual design to govern GMO-freeness, the next section focuses on the theoretical foundations of the establishment of cooperative GMO-free zones.

4 Factors determining the establishment of GMO-free zones

The cultivation of GM crops can lead to spatial externalities (Munro, 2008), mainly caused by the probability of cross-pollination between GM crops and adjacent non-GM crops. As laid down in the German Act on Genetic Engineering (Gentechnikgesetz, GenTG), the property rights are assigned to the non-GM farmer. Accordingly, the GM farmer has to take measures of ex-ante regulation to reduce the probability of cross-pollination to neighbouring fields and is ex-post liable for damages to third parties (Consmüller et al., 2009). From this regulation, coexistence costs for the GM-farmer may arise. However, also the non-GM farmer can be confronted with costs for e.g. laboratory analyses to prove the GMO-free status of his products which are not refunded (Then and Lorch, 2009). According to Jank et al. (2006), a significant reduction of these costs can be achieved if the two production types are spatially segregated into zones of GM-crop production and zones of GMO-free production. Skevas et al. 2010 could demonstrate that cooperation among GM farmers in Portugal significantly reduces coexistence costs. The same holds true for GMO-free production. Pirscher (2006) refers to damage costs which constitute the main incentive for the formation of GMO-free zones. Beyond that, laboratory costs for GM analyses or the costs of keeping retain samples may arise to the non-GM farmer to prove the purity of his product (Bullock and Desquilbet, 2000). Therefore, spatial agglomeration for GMO-free production might also act as a cost reducing approach under certain preconditions.

Against this background, we turn to the theoretical question which factors could have influenced regional formation cooperative GMO-free zones in Germany from 2004 to 2007.

Bt maize MON810 received market approval in the EU in 1998. Therefore, also in Germany, deliberate releases were pending, which resulted in temporal cultivation from 2005 to 2008.

Hence, a German conventional farmer could take the decision whether to switch to Bt maize or not. In economic terms, this decision depends on inner-farm cost-benefit calculations but is also influenced by external factors as could be demonstrated by Consmüller et al. (2010). Under the German regulatory framework, regional adoption of Bt maize in Germany is positively linked to ECB occurrence and size of the maize fields. The number of BUND[1] members, on the contrary, had a negative influence on adoption rates. Theoretically, a farmer can also decide not to grow GM crops at all. This may be driven by the fact that he produces organically which does not allow him to switch. Beyond that, he might reject the cultivation of GM crops for personal reasons. The establishment of GMO-free zones, however, is an act of collective action and thus necessarily involves more than just one farmer. The decision to form a GMO-free zone thus needs coordination with adjacent farmers in order to establish a spatially coherent area of GMO-free agricultural production.

As statistics on the cultivation of Bt maize in Germany reveal, only a very small percentage of German farmers actually adopted Bt maize (Consmüller et al. 2010).

A necessary precondition for the spatial formation of a GMO-free zone is low opportunity costs of not switching to Bt maize. This is mainly the case for organic farmers, who are not allowed to grow GM crops at all. Beyond that, Bt maize adoption is unattractive in those regions where either maize production is of minor importance and the target pest, the European Corn Borer, only causes minor to no damages. In addition, the collective action of forming a GMO-free zone can directly be linked to increased benefits for the involved farmers. Benefits mainly arise where farmers rejecting GM crops face a high probability of damages either by imminent Bt maize cultivation in the vicinity or due to small structured agriculture which renders the implementation of coexistence measures more difficult and less effective (Pirscher, 2006). Furthermore, a GMO-free zone might be able to increase the attractiveness of a region for tourists. Collective action to form a GMO-free zone is cost intensive, since for instance, adjacent neighbours have to be convinced to join the initiative and meetings have to be organised to maintain the structure. Certain actors can positively influence the cost dimension by providing infrastructure or help.

We take these considerations as a starting point for the deduction of suitable parameters for our econometric analysis and describe them in further detail below.

[1] BUND abbreviates Bund für Naturschutz Deutschland (Friends of the Earth Germany).

Category I: Low opportunity costs to participate in a GMO-free zone

Organic farming

According to Beckmann and Schleyer (2007), the share of organic farms in a region could be an indicator for the beneficial establishment of a GMO-free zone. Organic farmers have no incentives to grow Bt maize because it is not allowed to make use of GM technology. Therefore, opportunity costs to join a GMO-free zone are very low. In Germany, the labelling threshold of 0.9% for adventitious and technically unavoidable GMO traces also applies to organic production. However, many firms prescribe a labelling threshold of 0.1% which leads to additional costs of monitoring, if Bt maize cultivation takes place nearby. Therefore, for organic farmers high incentives exist to join a GMO-free zone in order to reduce potential on-farm coexistence costs which are not covered by the legislatory framework. We therefore argue that in regions with a high percentage of organic farms, there is also a higher probability for the establishment of GMO-free zones.

Maize area per farm

In line with the argumentation of Beckmann and Schleyer (2007) we assume that opportunity costs of joining a GMO-free zone are also reduced if maize area per farm is low. Neither is the occurrence of the ECB problematic in this case nor is there an incentive to switch to Bt maize production. Therefore, we expect the establishment of GMO-free zones in those areas where maize production is generally of minor importance.

Dynamics of the European Corn Borer (*Ostrinia nubilalis* Hübn.)

As could be demonstrated by Consmüller et al. (2010), regional Bt maize cultivation in Germany is positively correlated with the occurrence of the target pest, the European Corn Borer. This is not surprising since Bt maize functions as a plant protectant against the larvae of this maize pest. High infestation rates have been reported from southern parts of Germany, e.g. Bavaria and Baden-Wuerttemberg (Degenhardt et al., 2003). However, in recent years, the pest has been spreading northwards, with the federal state of Schleswig-Holstein being the last one in Germany with only minor to no incidence. Some areas are known for especially high infestation rates, such as the Franken region in northern Bavaria and the Oderbruch region in eastern Brandenburg (Schröder et al. 2006). With regards to the formation of GMO-free zones, Beckmann and Schleyer (2007) pointed out that these are likely to be established in regions where the European Corn Borer is only of minor importance because growing Bt maize not economically reasonable.

Category II: Increased benefits from joining a GMO-free zone

Imminent Bt maize cultivation in the vicinity

GMO-free zones understand themselves as the most efficient measure to guarantee long-term GMO-free farming (Nischwitz et al., 2005). We therefore assume that the development of GMO-free zones is also driven by the potential threat of GM crop cultivation in the vicinity. Since the cultivation of Bt maize has to be announced in a federal register at least three months prior to seeding, potentially affected farmers could react immediately to this threat by establishing a GMO-free zone. We therefore take the cultivation of Bt maize in the same year as another driving factor for the formation of a GMO-free zone.

Farm size

Coexistence is difficult to implement in small structured areas (Consmüller et al. 2010). According to Cooper (2009), many German small farmers oppose to GM technology because they fear that pollen from nearby grown GM crops could outcross with their crops and reduce their market value. Small and medium sized farms are beyond that also organized in associations which promote the establishment of GMO-free zones (Cooper, 2009). According to Beckmann and Schleyer (2007), actors can derive an economic benefit from a cooperative GMO-free zone if participation reduces the probability of lawsuits among neighbouring farmers. The risk of being involved in a law suit because of gene outcrossing due to GM crop cultivation highly depends on agricultural structures, such as small farms. We therefore hypothesize that small farm structures favour the establishment of GMO-free zones because coexistence between production forms is more difficult to guarantee and there is a high incentive for clustering to form a GMO-free zone.

Tourism

Since only 22% of the German population would support GM food (Eurobarometer, 2010), different actor groups have time and again emphasized the potential negative influence of GM crop cultivation on local tourism. Tourism can thus be perceived as a regional service whose provision is favoured by the establishment of a cooperative GMO-free region (Jank et al., 2006). We therefore assume that local actors engage in the establishment of GMO-free zones if the region already has a high touristic attractiveness or if actors assume that the touristic attractiveness of a region can be increased by this measure.

Category III: Reduced costs of collective action

Support by external stakeholders

Not only increasing benefits can favour the establishment of GMO-free zones but also reduced costs. Since a cooperative GMO-free zone comes into being through cost-intensive collective action, we assume that also cost-reducing factors might lead to a successful foundation of a GMO-free zone. Consmüller et al. (2010) found a negative effect of anti-GMO-activists, namely members of Friends of the Earth Germany (BUND) on regional adoption of Bt maize. The German platform on GMO-free zones (www.gentechnikfreie-regionen.de) is jointly organized by BUND and the Consortium on Rural Agriculture (AbL, Arbeitsgemeinschaft bäuerliche Landwirtschaft). They actively support the establishment of cooperative GMO-free zones by providing information and guidance through their website. Nischwitz et al. (2005) report regionally different engagements of local farmers' unions (Landesbauernverbände) in relation to the establishment of GMO-free zones. The authors report, that in Bavaria and Baden-Wuerttemberg, most GMO-free zones were fundamentally supported by the farmers' union. Such an engagement could not be observed in the Northern and Eastern parts of Germany. Taking all aspects together, we assume that a high regional incidence of anti-GMO activists can positively influence the establishment of GMO-free zones for the following reason: They can make use of existing infrastructures to coordinate the establishment and maintenance of GMO-free zones and thus reduce the costs of cooperation, e.g. through internet platforms and their knowledge on how to mobilize the public (see also Cooper, 2009). Due to a lack of data, we have to confine our analysis to the number of BUND members as an indicator for reducing the costs of collective action.

5 Data and econometric model

The previous hypotheses were tested by using a panel dataset at the federal state level. This database includes regionally aggregated information about the area under GMO-free zones and various structural and socioeconomic variables for the years 2004 to 2007.[2] Data on GMO-free zones was taken from the corresponding website (www.gentechnikfreie-regionen.de). Data on ECB infested area is taken from Deutscher Bundestag (2006). Data on agricultural area under Bt maize cultivation was obtained from the public site register at the Federal Agency for Consumer Protection and Food Safety (Bundesamt für Verbraucherschutz

[2] The city states Berlin, Bremen and Hamburg were omitted from the analysis.

und Lebensmittelsicherheit). Data on BUND members are taken from the annual reports of the association. All other data are official statistics provided by federal and state statistical offices. Descriptive statistics are summarised in Table 1.

Table 1: Descriptive statistics

Variable name	*Mean*	*Std. dev.*	*Min*	*Max*
GMO-free zones (thousand ha)	90.7	199.8	0.0	846.8
ECB infested area (thousand ha in 2005)	28.7	47.0	0.0	180.0
Bt maize cultivation (ha)	76.4	224.8	0.0	1346.8
Average farm size (ha)	97.2	84.7	22.9	263.7
Maize area per farm (ha)	7.6	6.1	0.9	20.5
Organic farming area (thousand ha)	62.1	42.4	5.2	146.5
Arriving tourists (million persons)	9.1	6.5	0.7	26.4
BUND members (thousand persons)	27.4	45.4	1.1	171.0
N	52			

Notes: Data covers years from 2004–2007.

Source: Authors' calculations based on sources given in the text.

We test the hypotheses outlined in the previous section, by using a linear regression model:

$$y_{it} = x_{it}^{\prime}\beta + \varepsilon_{it}, \quad i = 1,\ldots,N, \quad t = 1,\ldots,T., \quad (1)$$

where y_{it} is hectares under GMO-free zones for given regions and years, x_{it} is a vector of determinants, β the vector of coefficients that is to be estimated, and ε_{it} a conventional, identically and independently distributed error term. Estimated confidence intervals for β allow to statistically test the above hypotheses. *N* is the number of regions and *T* the number of years.

Among the explanatory variables, the ECB infestation rate is an important factors determining the private benefits of Bt maize cultivation. Unfortunately, systematic and complete annual data on ECB infestation rates is missing. At the federal states level, the Federal Government of Germany provided information on infestation rates only for the year 2005. This indicator displays the area of maize in ha on which at least 10% of the plants are infested by the ECB. For the variable organic farming area, farm size and maize area per farm, data for 2004 and 2006 was not available and was thus linearly interpolated from 2003, 2005 and 2007. As an indicator of the strength of the anti-GMO movement we use the absolute number of BUND members.

Estimating consistent parameters in equation (1) raises a number of methodological problems. First, the various states differ considerably with regard to the absolute area of GMO-free zones. One reason may be the principal differences in utilized agricultural area per state. Furthermore, there might be important latent variables that have an impact on y_{it}, such as regional differences in preferences for GM crop cultivation, or other unobserved abilities and preferences of farmers and citizens. Second, some variables in x_{it} may not be independent of the establishment of GMO-free zones. Notably, this could be the case for BUND membership which might have increased in response to impending or actual Bt maize cultivation in a given region, together with or prior to the establishment of GMO-free zones. Both problems will make ε_{it} no longer independently distributed, so that estimates of β are inconsistent. Furthermore, there are eight observations with zero GMO-free zones in the dataset, so that censoring may bias the results of a linear model.

The latter of these concerns was addressed by estimating the regression model using a Tobit approach that takes censoring into account (Greene 2008, p. 871). However, the differences to ordinary least-squares (OLS) regression were minimal. Furthermore, problems of size effects and latent heterogeneity were addressed by estimating a fixed effects version of equation (1). As a consequence, β captured only the effect of relative changes in x_{it} on y_{it}, independent of the absolute size of GMO-free zones. Effects due to size or latent preferences are eliminated in this way. To the extent that they were time invariant, the effects of all endogenous determinants of y_{it} were also eliminated. In order to capture this benefit, we did not consider a random effects specification any further, because it assumes that unobserved effects are uncorrelated with the other right-hand variables (Greene 2008, p. 200). Due to the so-called incidental parameter problem, there are unresolved methodological issues in estimating Tobit models that include fixed effects (Greene 2008, p. 882). We therefore did not address censoring and unobserved heterogeneity within one model. Furthermore, the time invariant variable ECB infestation rate was omitted in the fixed-effect model. Because it was highly correlated with the absolute number of BUND members (with a partial correlation coefficient of 0.963), problems of multicollinearity prevented us to include both variables at the same time in the OLS model. In order to control for changes in the overall environment that are identical for all regions, such as in per capita income or other macro variables, we also included year dummies in all models.

6 Results

In Table 2, we present estimation results for two models. Model A presents the results of a pooled OLS model with period effects, whereas model B represents a linear fixed-effects model that also takes possible regional and time effects into account. Results for the Tobit model are not shown, as the difference to model A was minimal. As shown by the R^2, both models can explain a substantial part of the variation in the dependent variable.

Table 2: Regression estimates for GMO-free zones in the German federal states

Explanatory variables	***Pooled OLS (A)***			***OLS with regional fixed effects (B)***		
	Coefficient		p-*value*	*Coefficient*		p-*value*
ECB infested area (thousand ha in 2005)	3.779	***	0.001	-		
Bt maize cultivation (ha)	-0.017		0.427	0.026	**	0.037
Average farm size (ha)	-0.339		0.108	0.228		0.614
Maize area per farm (ha)	2.851		0.380	-5.133		0.200
Organic farming area (thousand ha)	-0.101		0.754	0.898		0.287
Arriving tourists (million persons)	3.113	**	0.038	26.131	**	0.021
BUND members (thousand persons)	-			15.108		0.136
Year = 2005 (dummy)	7.796		0.669	-9.960		0.387
Year = 2006 (dummy)	23.882		0.246	0.415		0.964
Year = 2007 (dummy)	27.909		0.240	-13.250		0.387
Constant	-42.009	*	0.069	-595.517	**	0.046
R^2	0.948			(within) 0.713		

Notes: Model (B) based on deviations from state averages. *, **, ***: significant at 10%, 5%, 1% level. (A) uses robust standard errors, standard errors in (B) are robust to clustering in groups. N=52 for all regressions.

Source: Authors' calculations.

The results from the two models consistently demonstrate the importance of ECB infestation and current Bt maize cultivation as drivers of GMO-free zones expansion. A second significant factor is the number of arriving tourists. Note that this carries over to the fixed effects model B. This is evidence that the relationship is not the spurious result of a simple size effect, i.e. bigger states have bigger GMO-free zones and more tourists. It was rather the relative increase of visitors independent of its absolute level that had a significant impact on the expansion of GMO-free zones. On the other hand, farm structures and cultivation practices other than GMO use had little influence on the establishment of GMO-free zones. The effect of BUND membership turned out positive in model B, but did not pass the ten percent level of significance. The presence of anti-GMO activists as measured by this variable hence tends to have only a weak effect on the growth of GMO-free zones.

7 Conclusions

A first main result of the empirical investigation is that ECB occurrence tends to reinforce the establishment of GMO-free zones. At first glance, this finding contradicts the considerations of Beckmann and Schleyer (2007). The authors assumed that the formation of GMO-free zones was more likely in regions where the target pest pressure was of minor importance because under these circumstances, no economic incentives existed to switch to Bt maize cultivation. Indeed, this might have been the case in the early stages of GMO-free zone formation, where the opportunity costs for the establishment of a GMO-free zone were regarded as being low. Beyond that, cultivation of Bt maize was not yet an option because the event received its approval for commercial cultivation in 2005. Since we also considered data from those years where Bt maize cultivation was already legally possible, the mere occurrence of the target pest was apparently interpreted by local actors as an omen for imminent Bt maize cultivation in the near vicinity. This point of view is furthermore supported by the significantly positive influence of actual Bt maize cultivation on the establishment of GMO-free zones. According to our results, the cooperative establishment of GMO-free zones is not only a political statement but also a direct reaction to a perceived change in landscape use. Apparently, local actors try to halt undesired landscape change by collective action. This brings us to the question of economic drivers for this cost-intensive collective action. Initially, we assumed, as also supported by Beckmann and Schleyer (2007), that local actors derive economic benefits from collective action which outweigh the costs. GMO crop cultivation is costly in terms of coexistence measures. Especially in areas with a high percentage of organic farms and small scale agricultural structures, coexistence can turn out to be cost intensive (Messean et al., 2006). In this case, cooperation to form a GMO-free zone could be regarded as a cost-saving alternative. However, our analysis does not support this hypothesis, since neither the share of organic farms nor the average farm size appeared to have an influence on the regional formation of GMO-free zones.

Our analysis reveals a positive influence of tourism on the regional establishment of GMO-free zones. This relationship has not been investigated so far, although a positive influence has already been suggested by Jank et al., 2006. Beyond that, from time to time newspaper statements point at the fact that local administrations fear a negative effect on regional touristic attractiveness if GM crops are cultivated (Frankfurter Neue Presse, 2011; MVRegio, 2011). The effect can be interpreted in two ways: on the one hand, the establishment of a GMO-free zone could be regarded as a measure to attract more tourists to a certain region and thus to increase economic benefits for local stakeholders. Establishing a GMO-free zone can create a positive image for local agriculture, especially for regions which have also been known for large scale agriculture, such as the former East German federal states. This is in line with the considerations of Beckmann and Schleyer (2007), who discuss marketing advantages as one driving force for the formation of GMO-free zones.

On the other hand, it could be argued that regions with a long tradition in tourism might fear to lose their attractiveness due to Bt maize cultivation. In this case, the formation of a GMO-free zone can be interpreted as a measure to halt this development and to sustain existing economic benefit streams. This could be the case for those landscapes, where tourism has always been an important source of income (e.g. Southern Bavaria).

In our theoretical considerations we assumed a significant influence of external stakeholders, mainly anti-GMO activists, on the establishment of GMO-free zones. In our analysis this parameter could only be empirically represented by Friends of the Earth Germany (BUND), since data on other relevant stakeholders, such as AbL and local farmers’ unions was unavailable. BUND actively engages in the dissemination of information about GMO-free zones through their website. They also provide active help with contract design. The provision of this kind of infrastructure was regarded as being helpful to reduce the costs of collective action and favour the establishment of GMO-free zones. Beyond that, Consmüller et al. (2010) could demonstrate a negative effect of BUND members on regional adoption of Bt maize. However, our empirical analysis only indicates a significant influence of this parameter at the 15% level. One explanation for this finding is that, as we laid down in chapter 3, BUND members are by far not the only stakeholders active in the formation of GMO-free zones. Further investigations of this parameter should be carried out by taking the role of the AbL as well as the local farmers' unions into account. GMO-free zones are likely to have a high support from the local community if their concerns are addressed by a variety of stakeholder groups which recruit their members from different sections of the population. BUND members are linked to the environmental movement whereas AbL addresses small farms. Being able to rely on the farmers' union for the establishment of GMO-free zones also seems to be very effective especially in those areas where many farmers hold a membership and the farmers' union has a good standing in the local community.

Overall, our analysis suggests that the imminent or actual expansion of GM crops in a certain region was an important driver of the creation of GMO-free zones in this region. To the extent that this can be identified by a regionally aggregate empirical analysis, the previous factor appears to dominate more farm-specific determinants influencing the costs of uncertainty and coexistence. This finding is consistent with the view that it is more the overall rejection of agro-biotechnology by broad strata of the population, including stakeholders in tourism and environmental protection, than economic benefits at the farm level which make German regions establish GMO-free zones.

8 References

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