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How can specific market demand for non-GM maize affect the profitability of Bt and conventional maize? A case study for the middle Ebro Valley, Spain

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Abstract

This article analyses the consequences that a specific new market for non-GM (genetically modified) compound feed would have on the relative profitability of Bt and conventional maize in the middle Ebro Valley (Spain). The study uses information obtained through a survey amongst maize farmers for the year 2009. This paper evaluates the current profitability of Bt maize relative to the profitability of conventional maize showing that at present the probability of Bt maize being more profitable than conventional maize is 100%, mainly due the significantly higher yields of Bt maize. In addition the future of Bt maize is analysed in the event that a specific demand for non-GM maize for feed emerges. Simulations of price premium for conventional maize and their impact on the profitability of Bt maize in the region are described. To reduce to 50% the probability of Bt maize being more profitable than conventional maize a price premium of €17 ton^{-1} for non-GM maize would be necessary.

Additional key words: bootstrapping; compound feed; genetically modified maize; Monte-Carlo simulation; price premium; price scenarios; *Zea mays* L. line MON810.

Resumen

¿Cómo puede afectar la demanda de maíz no modificado genéticamente a la rentabilidad del maíz Bt y del convencional? Un caso de estudio para el Valle medio del Ebro (España)

Este trabajo analiza las consecuencias que podría originar la aparición de un nuevo mercado de piensos no modificados genéticamente en la rentabilidad relativa del maíz Bt y convencional en el Valle medio del Ebro (España). Para el análisis se utiliza información obtenida de los agricultores de maíz a través de una encuesta realizada durante el año 2009. El trabajo evalúa la rentabilidad actual del maíz Bt en relación a la rentabilidad del maíz convencional mostrando que la probabilidad de que el maíz Bt sea más rentable que el convencional es del 100%, debido en su mayor parte a los mayores rendimientos del maíz Bt. Además se analiza el futuro del maíz Bt ante la posibilidad de que aparezca una demanda específica para piensos no modificados genéticamente. Se realizan simulaciones de sobreprecios del maíz convencional y se analiza el impacto que éstos tendrán sobre la rentabilidad del maíz Bt. Para reducir al 50% la probabilidad de que el maíz Bt sea más rentable que el maíz convencional será necesario un incremento de 17 € ton^{-1} para el maíz no modificado genéticamente.

Palabras clave adicionales: bootstrapping; escenarios de precios; maíz modificado genéticamente; piensos; simulación Monte-Carlo; sobreprecio; *Zea mays* L. línea MON810.

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Abbreviations used: Bt (Insect-resistant); GM (genetically modified); GMO (genetically modified organism).

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Introduction

European and Mediterranean corn borers (*Ostrinia nubilalis* and *Sesamia nonagrioides* respectively) are two of the main pests affecting maize (*Zea mays* L.) production in Europe, causing major economic losses due to lower yields. The chemical control of these two species is particularly difficult since insecticide sprays are only effective during the short period which elapses between the eggs hatching and the larvae boring into stems (Farinós *et al.*, 2004; Agustí *et al.*, 2005). Insect resistant (Bt) maize (*Zea mays L. line MON810*) can effectively control these two main pests and therefore reduce the yield losses associated with them (Demont & Tollens, 2004). In the presence of the pest this yield advantage exceeds the technology price gap (*i.e.* difference between Bt and conventional seed prices) and may result in high profitability of Bt maize when compared to its conventional counterpart (Gómez-Barbero *et al.*, 2008; Areal *et al.*, 2012). Regardless of the profitability of Bt maize and twelve years after the introduction of GM crops in the European Union (EU), the cultivation of Bt maize for commercial use reached 91,193 ha (James, 2011) which represented 2.3% of the total grain maize area in the EU-15 and 1.7% of the total grain maize area in the EU-25 (Eurostat, 2012) (see Fig. 1).

Bt maize is only planted in six EU countries: Spain, the Czech Republic, Portugal, Romania, Poland and Slovakia while its cultivation is banned in countries such as Austria, France, Germany, Greece, Hungary and Luxembourg. One of the reasons for the low adoption rate of Bt maize in the EU is low consumer demand and public trust in the technology compared with conventional crops (Sabalza *et al.*, 2011). Spain is the largest producer of Bt maize in the EU with 84% of the total Bt maize area in the EU in 2010 (James, 2011). Since 1998, the area of Bt maize has grown consistently reaching an adoption rate of Bt maize at around 24% of the total maize area in 2010 (MAGRAMA, 2012a). In Spain, Bt maize is grown mainly in Aragon and Catalonia, as it is shown in Table 1. The higher adoption of Bt maize (ratio of Bt maize over total maize) in these areas can be considered as an indicator of high corn borer pressure.

Most Bt maize is used in animal feed and currently all compound feed sold in Spain is labelled as genetically modified (GM) with the exception of organic feed (Brookes *et al.*, 2005). However, as in other EU countries a specific new market for non-GM compound feed may emerge also in Spain (Brookes *et al.*, 2005). Some EU countries such as Austria, France, Ireland and UK provide a voluntary GM-free label for food and livestock produced with certified non-GM ingredients. In such a situation, in which meat derived from animals fed with non-GM crops can be identified, it is possible that consumers in Spain would begin to demand this type of meat. Indeed, the Eurobarometer reveals that

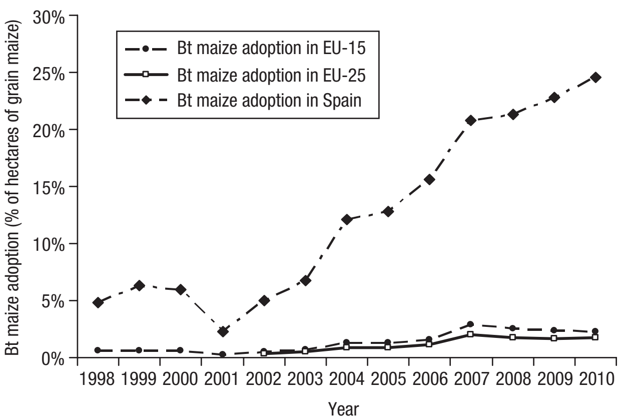

Figure 1. Bt maize adoption (% of hectares of grain maize) in the EU-15, EU-25 and Spain.

Table 1. Hectares of Bt maize and maize[1] in Spain per region, 2009[2]

	Bt maize *(a)* (ha)	Maize *(b)* (ha)	Bt maize/ Maize *(a/b)* (ha) (%)
Andalusia	2,084	24,587	8.5
Aragon	***31,397***	***66,107***	***47.5***
Asturias	0	300	0.00
Baleares	110	525	21.0
Basque Country	0	453	0.0
Cantabria	0	92	0.0
Canary Islands	0	649	0.0
Castilla-La Mancha	3,417	32,108	10.6
Castilla-Leon	0	103,299	0.0
Catalonia	***29,218***	***38,179***	***76.5***
Ceuta & Melilla	0	1	0.0
Extremadura	8,730	43,069	20.3
Galicia	0	18,701	0.0
La Rioja	8	747	1.1
Madrid	50	5,850	0.9
Murcia	0	112	0.0
Navarra	4,691	13,413	35.0
Valencia	0	758	0.0
Total Spain	**79,706**	**329,146**	**24.2**

[1] Maize hectares include both Bt and conventional grain maize.
[2] MAGRAMA (2012a,b). See hectares of Bt maize and maize in the middle Ebro region (Aragon and Catalonia) in bold italics.

the majority of Europeans mistrust genetically modified organisms (GMOs) (61%) while approximately 23% supports their use (Gaskell *et al.*, 2010). Such mistrust is possibly partially behind consumers being willing to pay a premium for non-GM products (Magnusson & Hursti, 2002; Lusk *et al.*, 2003, 2004, 2005; Moon & Balasubramanian, 2003; Costa-Font *et al.*, 2008).

In this paper we analyse the consequences that this new market for non-GM compound feed would have on the relative profitability of Bt and conventional maize (*i.e.* what should be the price premium for non-GM maize in order to erode the relative profitability of Bt maize). The area under analysis is the middle Ebro Valley (Aragon and Catalonia) due to its relatively high adoption rate of Bt maize at Spanish and EU level.

Material and methods

Profitability of Bt and conventional maize was evaluated through partial gross margins analysis. Partial gross margin is defined as the difference between farmer's income and those variable costs which may be different in Bt and conventional maize production (*i.e.* seed and pesticide costs). Other variable costs not affected by the choice of Bt or conventional maize production were not included in the partial gross margin analysis (*i.e.* costs which may not be different between both crops, such as herbicide treatments, fertilizers and energy and water use).

A survey amongst maize farmers in the middle Ebro Valley[i] was conducted between June and July 2010 to obtain data on farm characteristics, cropped area, yields, prices and production costs as well as the farmer's socio-demographic profile for year 2009. This information allowed us to evaluate the current profitability of Bt maize relative to the profitability of conventional maize and to build a baseline scenario to simulate changes in the prices of Bt and conventional maize.

A total of 85 farmers in Aragon and Catalonia were interviewed by telephone[ii] (28 farmers growing conventional maize and 57 farmers growing Bt maize). The minimum sample size for maize growers was calculated using the formula [1][iii] (Litwin, 1995):

$$n = \frac{\sum_{h=1}^{L} W_h^2 \cdot \frac{N_h}{N_h - 1} \cdot \frac{P_h Q_h}{w_h}}{\frac{e^2}{k^2} + \frac{1}{N^2} \sum_{h=1}^{L} \frac{N_h^2}{N_h - 1} \cdot P_h Q_h} \qquad [1]$$

where n is the minimum number of total surveys for maize, L is the number of regions where maize is analyzed (two regions); N is the total number of farms that cultivate grain maize in the middle Ebro Valley (Aragon and Catalonia); N_h represents the total number of farms producing grain maize in region h; W_h is the population weight of grain maize in region h (N_h/N); w_h is the sample weight of grain maize in the region h; P_h is a ratio representing the weight of farms that produce maize in a region, which is calculated as the number of farms producing maize divided by the total number of holdings in region h; Q_h is the ratio of farmers growing other crop than maize in region h; e is the maximum sample error allowed; and k is the confidence level at 90%. The number of farms per region for grain maize was obtained from the Spanish National Statistics Institute (INE, 2012).

We assume the most adverse values of P_h and Q_h to estimate the variance of the stratum (middle Ebro Valley), *i.e.* we considered $P_{ih} = Q_{ih} = 0.5$. This choice ensures a significant sample size with regard to the variance of the strata (regions). In order to ensure that the two regions are adequately represented we gave the same weight to each proportional weight. Thus, the size of the total survey is distributed proportionally based on the size of strata, *i.e.* $W_h = w_h$.

Tables 2 and 3 show the number of interviews done in Aragon and Catalonia, the area of conventional and Bt maize by region (MAGRAMA, 2012a,b) and the weights associated to each region.

Due to the lack of data on the number of Bt and conventional maize farms, we used regional data on maize area. Taking into consideration each region's maize area relative to both conventional and Bt maize area in the middle Ebro Valley two sets of weights were

[i] The middle Ebro Valley is located in the Northeast of Spain and it is characterised by a Mediterranean climate. This is one of the major maize-growing areas in Spain with 104,000 ha (around 30% of the Spanish maize area in 2009).

[ii] These two regions are adequately represented at the middle Ebro Valley level considering a 90% confidence level (k = 1.64) and a permissible maximum error of 9% (e = 0.089).

[iii] Sample size calculations are based on the number of maize farms in Aragon and Catalonia in 2009 (INE, 2012). However it was not possible to obtain a minimum sample size per each variety of maize since there are no data available about the number of conventional and Bt maize farms at regional level.

Table 2. Number of responses of conventional maize farmers collected in the middle Ebro Valley

Conventional grain maize				
	No. of responses in the survey *(a)*	**Conv. survey weight (%) *(a/b*100)***	**Conv. maize (ha) (2009) *(c)***	**Conv. regional weight (%) *(c/d*100)***
Aragon	26	93	34,710	80
Catalonia	2	7	8,961	20
Total	28 *(b)*	100	43,671 *(d)*	100

Taking into consideration each region's maize area relative to the total area in the middle Ebro Valley (Aragon and Catalonia regions) we obtained regional weights [*i.e.* for each region, regional weights were calculated by dividing maize hectares in each region (*c*) by the total maize hectares in the middle Ebro Valley (*d*)]. We calculated the survey weight for each region by considering the number of responses for conventional maize in each region relative to the total responses obtained in the middle Ebro Valley [*i.e.* for each region, survey weights were calculated by dividing the number of responses collected in each region (*a*) by the total responses collected in the middle Ebro Valley (*b*)].

Table 3. Number of responses of Bt maize farmers collected in the middle Ebro Valley

Bt grain maize				
	No. of responses in the survey *(g)*	**Bt survey weight (%) *(g/h*100)***	**Bt maize (ha) (2009) *(i)***	**Bt regional weight (%) *(i/j*100)***
Aragon	53	93	31,397	52
Catalonia	4	7	29,218	48
Total	57 *(h)*	100	60,615 *(j)*	100

Taking into consideration each region's Bt maize area relative to the total Bt maize area in the middle Ebro Valley we obtained normalised regional weights [*i.e.* for each region, regional weights were calculated by dividing Bt maize hectares in each region (*i*) by the total Bt maize hectares in the middle Ebro Valley (*j*)]. We calculated the survey weight for each region by considering the number of responses for Bt maize in each region relative to the total responses obtained in the middle Ebro Valley [*i.e.* for each region, survey weights were calculated by dividing the number of responses collected in each region (*g*) by the total responses collected in the middle Ebro Valley (*h*)].

calculated for each region, regional and survey weights (Tables 2 and 3). Regional weights represent the importance of conventional and Bt maize areas in each region relative to the whole of the middle Ebro Valley and survey weights represent the percentage of Bt and conventional maize farmers surveyed in each region relative to the whole dataset. In order to adjust the regional distribution of the dataset to the distribution of maize cultivation in the middle Ebro Valley, survey weights for both crops were matched with current regional weights of Bt maize and conventional maize area in the middle Ebro Valley. This was achieved by using non-parametric bootstrapping which consisted in drawing the observed data on incomes, seed costs and pesticide costs 1,000 times with replacement taking into account the normalised regional weights of each crop. We thus obtained a sample of 1,000 observations by variable and crop which matches the current regional weights of Bt and conventional maize. Normal distributions were specified for incomes and seed costs using the means and the standard deviations obtained from the bootstrapped sample[iv] as parameters of the distribution through Monte-Carlo methods. Normal distributions were assumed since observed data showed normal distributions for these variables (Kolmogorov-Smirnov tests were carried out to analyse normality and results showed that the variables prices, yields, income and seed costs followed a normal distribution for both crops). By contrast, a positively truncated normal distribution was specified for pesticide costs since data showed positively truncated normal distributions. Distribution of data by variable is shown in Fig. 2[v].

Bt and conventional maize profitability were computed by calculating the distribution for the mean partial gross margin of each crop:

$$\begin{gathered}\textit{Partial Gross Margin} = \\ = \textit{Income} - \textit{Seed costs} - \textit{Pesticide costs}\end{gathered} \quad [2]$$

where income is defined as maize price multiplied by yield. In order to obtain a distribution for the mean of the partial gross margin for each crop the simulation process was repeated 1,000 times. This allowed us to

[iv] The mean and standard deviation used for each Monte-Carlo simulation are reported in Fig. 2.

[v] Average grain maize price (€ 148.3 ton^{-1} in Aragon and € 143.00 ton^{-1} in Catalonia) and yield (10.41 ton ha^{-1} in Aragon and 9.07 ton ha^{-1} in Catalonia) reported by the Regional Ministries of Agriculture of Aragon and Catalonia for 2009 (MAGRAMA, 2012b; Regional Ministry of Agriculture of Aragon, 2012; Regional Ministry of Agriculture of Catalonia, 2012) are relatively close to the average of the distributions of collected data (see Fig. 2).

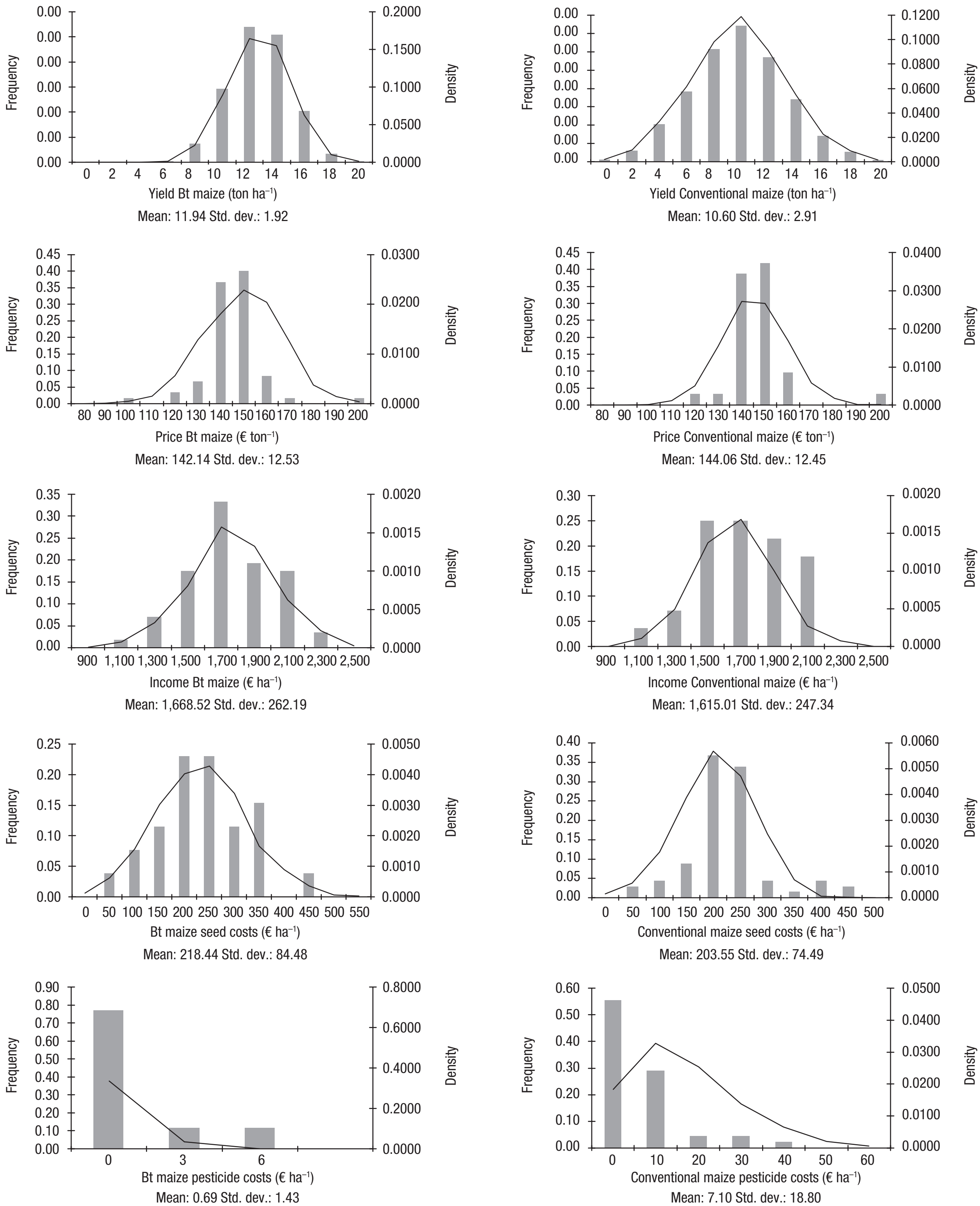

Figure 2. Raw data histograms and density plots (Baseline scenario). Histograms count the percentage of observations that fall into certain ranges of values or bins. Therefore histogram graphs show the distribution of data by variable (*i.e.* yield, price, income, seed costs and pesticide costs). Density plots show the construction of an unobservable underlying probability density function based on observed data.

compare the average partial gross margins of both crops and calculate the probability of one being larger than the other. More specifically we obtained this probability by subtracting each element of the Bt gross margin distribution from the conventional gross margin distribution and assigning 1 if the result was positive and 0 otherwise. The sum of the results divided by 1,000 gives us the probability of Bt maize being more profitable than conventional maize.

Results and discussion

Figure 3 shows the distribution for the mean partial gross margin of Bt and conventional maize. Distributions show a mean of €1,435 ha^{-1} for conventional maize and a mean of €1,530 ha^{-1} for Bt maize. We found that mean partial gross margins for Bt and conventional maize were statistically different (*i.e.* there was a 100% probability that the partial gross margin mean for Bt maize was greater than the partial gross margin mean for conventional maize). Significant positive differences between partial gross margin means confirm that, in the presence of the pest, Bt maize performed economically better than conventional maize after 12 years of cultivation in the middle Ebro Valley. Previous studies showed similar results at earlier stages of Bt maize adoption in Aragon (Gómez-Barbero *et al.*, 2008).

The partial gross margin analysis shows a €95 ha^{-1} mean difference between Bt and conventional maize.

In addition to the analysis of the current profitability of Bt maize and conventional maize in the middle Ebro valley, a comparative analysis on the profitability of Bt maize and conventional maize in the middle Ebro Valley was conducted by examining how much the prices and costs included in the partial gross margin would have to change in the market to make conventional maize more or equally attractive than producing Bt maize. Analysing results for 2009 (Fig. 2) and 2004 (Gómez-Barbero *et al.*, 2008) on Bt and conventional maize performance in Aragon and Catalonia, we can infer that yields of Bt and conventional maize are fairly stable in the medium term. Thus it is reasonable to assume that the difference in crop yields remains at 2009 levels. Given the baseline scenario (Fig. 2), we studied a set of scenarios of change in prices of Bt maize and conventional maize production. Our results showed that seed prices and pesticide costs have only a marginal effect on gross margin (Fig. 2). Indeed, distributions of the mean partial gross margins for each

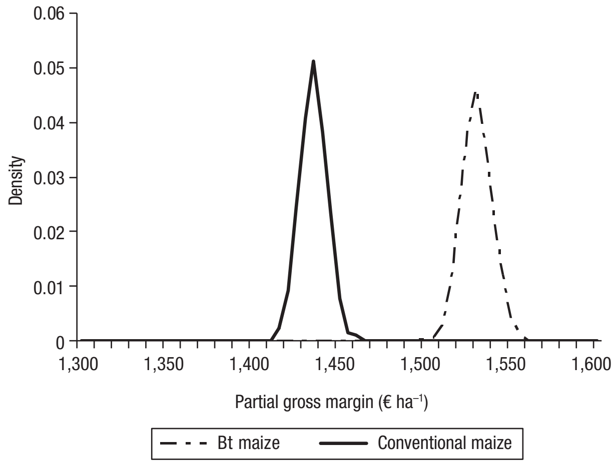

Figure 3. Mean partial gross margin distributions (Baseline scenario) for the middle Ebro Valley.

crop showed means seven times higher than the means of seed costs and more than 200 times higher than the means of pesticide costs. Therefore amongst the four variables determining partial gross margin (*i.e.* yields, maize prices, seed prices and pesticide costs) we only analysed changes in maize prices. In each of the price scenarios we used Monte-Carlo methods to obtain the probability of Bt maize being more profitable than conventional maize. The probability was obtained in the same way as explained at the end of the *Material and methods* section.

Scenarios regarding maize prices were based on the fact that both Bt maize and conventional maize are substitute crops (*i.e.* they may be replaced by each other in use). As it is mentioned above Bt maize in Spain, and consequently in the middle Ebro Valley, is sold mainly for compound feed production (Brookes *et al.*, 2005) and price scenarios aims to represent a new market for non-GM compound feed and thus a situation in which feed producers would be less willing to buy GM crops. For instance, scenarios may represent the expansion of the market of meat products labelled "derived from animals reared with non-GM crops", as occurs in other EU countries (Austria, France, Ireland and Germany) (O'Callaghan, 2009). As a result of an expected increase in consumption of meat from animals fed with non-GM crops by consumers, conventional maize demand by feed manufacturers may increase in the middle Ebro Valley. This increase in conventional maize implies a rise in both conventional maize price and quantity demanded (right-shift of the demand curve of conventional maize). Since conventional and Bt maize are substitute goods, an increase in the quantity demanded of conventional maize *ceteris paribus* leads to a decrease in the demand for Bt maize (left-shift of the demand curve for Bt maize). In the market for Bt maize this demand cut implies a lower price for the crop (see Fig. 4).

Considering economic theory, and taking into account that Bt and conventional maize demand elasticities are unknown (the demand elasticity is defined as the percentage change in quantity demanded resulting from a given percentage change in price when other influences on demand are held constant), three price scenarios were considered at farmer's level: 1) a fall in Bt maize price, from 1% to 15%, and a rise in conventional maize price at the same rate (*i.e.* Bt and conventional maize are considered as perfect substitutes), 2) a fall in Bt maize price, from 1% to 15%, and a rise in conventional maize price at half the rate of the fall in Bt maize price, from 0.5% to 7.5%, (*i.e.* we assume that conventional maize demand is more inelastic (or less sensitive to price changes) than Bt maize demand), and 3) a fall in Bt maize price, from 1% to 15%, and a raise in conventional maize price at one and a half times the rate of the fall in Bt maize price, from 1.5% to 22.5% (*i.e.* we assume that conventional maize demand is more elastic (or more sensitive to price changes) than Bt maize demand). Scenarios were built using Monte-Carlo simulations. We calculated the new gross margin distributions for each crop after shifting the means of the income distributions in the way described for each scenario. The new gross margin distributions are used to calculate the probability of Bt maize being more profitable than conventional maize for each scenario in the way described above. This process was carried out for the whole range in each scenario. For instance, for scenario 2 we considered a fall in Bt maize between 1% and 15% and a rise in conventional maize at half rate of the fall in Bt maize. Using this ranges, we calculated 15 new gross margin distributions for each crop. Consequently, for the first simulation a 1% fall in Bt maize price and a 0.5% raise in conventional maize price were assumed. The second simulation assumed a 2% fall in Bt maize price and a 1% raise in conventional maize, and so on.

We analysed the changes in farmers' mean partial gross margin distributions under these three scenarios for maize prices. Figure 5 shows how the probability of Bt maize performing better (*i.e.* higher partial gross margin) than conventional maize changes under different maize prices scenarios. Reducing the producer price of Bt maize, and therefore increasing the price of its conventional counterpart, causes the gap between mean partial gross margin distributions to narrow (*i.e.* lower distance between mean partial gross margin distributions of Bt and conventional maize than that shown in Fig. 3), hence there is a lower probability of Bt maize performing better. We can see that already slight changes in Bt and conventional maize prices imply a rapid fall in the probability of the Bt maize partial gross margin being greater than the conventional maize partial gross margin.

Results of scenario 1 show that a 3% drop in Bt maize price in combination with a 3% rise in conven-

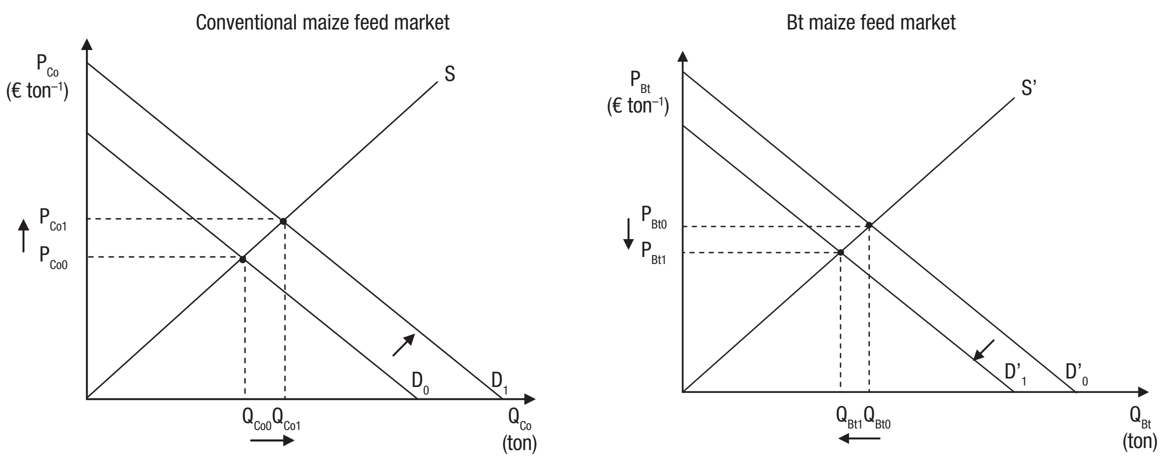

Figure 4. Scenarios for conventional and Bt maize in the feed market. D (D') represents feed producers demand for conventional (Bt) maize and S (S') represents farmers supply of conventional (Bt) maize. P_{Co} (P_{Bt}) shows the price of conventional (Bt) maize and Q_{Co} (Q_{Bt}) shows the quantity sold of conventional (Bt) maize in the feed market.

tional maize price means that the probability of Bt maize partial gross margin being greater than the conventional maize partial gross margin falls from 100% to 20% (see Fig. 5). Scenario 2 shows that the probability of Bt maize partial gross margin being greater than the conventional maize partial gross margin would fall from 100% to 12% for a 4% decrease in the price of Bt maize and a 2% increase in the price of conventional maize. Scenario 3 shows that the probability of Bt maize partial gross margin being greater than the conventional maize partial gross margin falls from 100% to 9% if there is a 2.4% decrease in the Bt maize price and a 3.6% increase in conventional maize price.

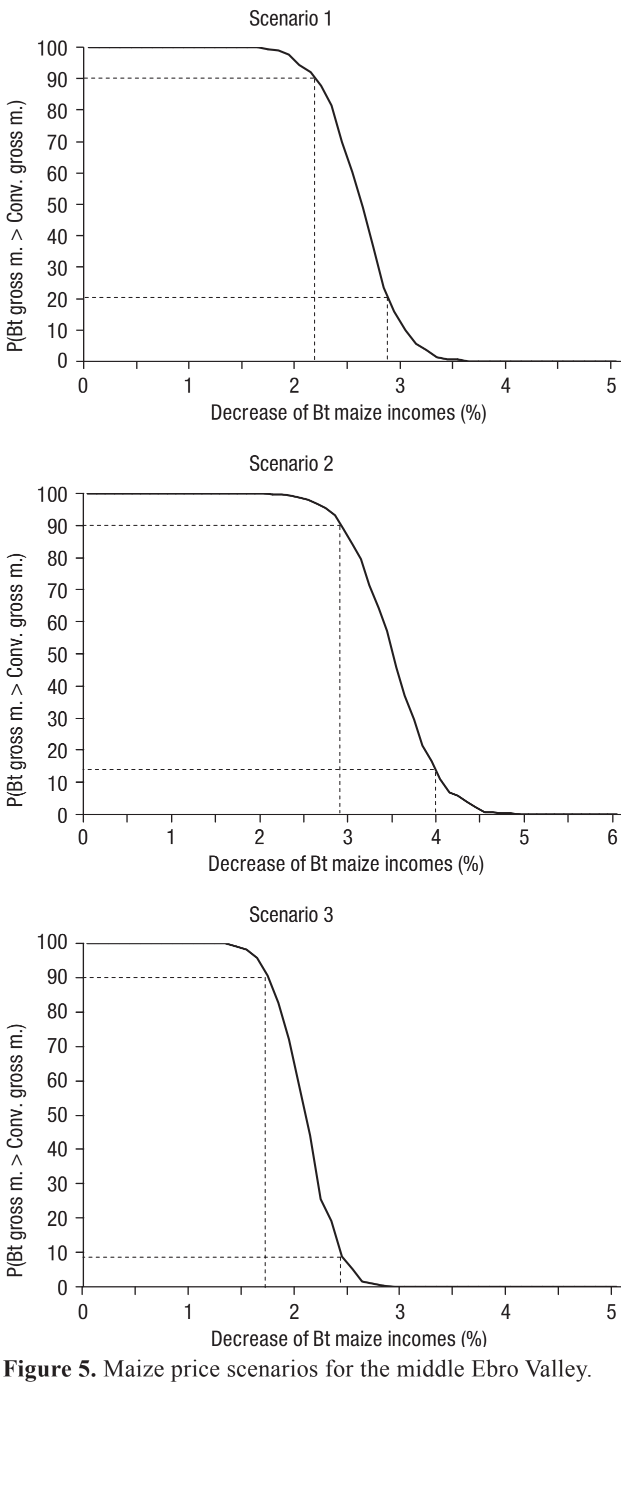

Figure 5. Maize price scenarios for the middle Ebro Valley.

Facing current market prices of Bt and conventional maize in the middle Ebro Valley, Bt maize is at present the best economic option for farmers affected by corn borers as adopting Bt maize avoids economic losses associated with low yields. However falls in Bt maize prices between 2.1% and 3.5% and simultaneous increases in conventional maize prices between 3.1% and 1.7% relative to the baseline scenario lead to a drop in the probability of Bt maize performing economically better than conventional maize from 100% to 50% (see Table 4). These changes in relative maize prices equal an average price premium of around €17 ton^{-1} for conventional maize. Our results are consistent with price premiums paid to conventional maize farmers in the United States that ranged from €14 ton^{-1} to €20 ton^{-1} in 2009 (Foster, 2010; Nowicki *et al.*, 2010).

It can be argued that the effects of the emergence of a new market for conventional maize for feed on the input costs faces a degree of uncertainty. In this regard while we acknowledge that not knowing such effect may dim our analysis we are confident that being uncertain about the effect of the emerge of a new market on input costs has a marginal impact on our results for the following reasons: a) the relative low weight of seed and pesticide costs in the partial gross margin for both Bt and conventional maize and b) it is likely that changes in the supply due to changes in input costs are relatively smaller than those changes in the demand due to the emergence of a new market (change in consumers' preferences).

We conclude that, in the event that a specific demand for non-GM maize for feed emerges in the middle Ebro Valley, small changes in relative prices of maize may cause a reduction of the profitability of Bt maize for

Table 4. Changes in maize prices which reduce the probability of Bt maize performing better than conventional maize by up to 50% in the middle Ebro Valley

	Bt maize price decrease (%)	Conventional maize price increase (%)	Respective price premium for conventional maize (€ ton^{-1})
Scenario 1	2.6	2.6	17.91
Scenario 2	3.5	1.7	16.34
Scenario 3	2.1	3.1	17.67

farmers which may make this crop no longer economically attractive. An emerging demand for non-GM maize for feed depends not only on a price premium paid by feed manufacturers for conventional maize but on the willingness of consumers to pay a price premium for products derived from animals reared with non-GM feed. As it is pointed out in the introduction, several studies in the EU support the willingness of the consumers to pay a premium for non-GM products. According to these studies and in the light of recent developments in other EU countries (Austria, France and Germany) two potential new markets may emerge in Spain and therefore in the middle Ebro Valley*, i.e.* a market for conventional maize for feed and a market for products derived from animals fed with non-GM feed. If this will be the case then already a price premium of around €17 ton^{-1} for non-GM maize will deteriorate the profitability of Bt maize in the middle Ebro Valley.

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