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The economics of adventitious presence thresholds in the EU seed market

Nicholas Kalaitzandonakes*, Alexandre Magnier

University of Missouri–Columbia, Economics and Management of Agrobiotechnology Center, United States

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A B S T R A C T

Since settling on its mandatory labeling rules for genetically modified (GM) foods in the late 1990s, the European Commission has considered a number of times setting tolerance levels (thresholds) for the accidental presence of GM material in conventional seeds. In every case, it has opted to defer the decision. In the absence of such thresholds, current European labeling laws require that seeds be labeled as GM if they contain any detectable trace of GMOs approved for cultivation in the EU. Conventional seeds with detectable traces of GMOs that have not been authorized for cultivation cannot be sold in the European market altogether. As the acreage of GM crops has continued to grow at a fast pace around the world, industry calls to the EU Commission for setting “practical” adventitious presence (AP) thresholds for conventional seeds in the EU have multiplied. In this paper, we examine the economics of alternative AP thresholds for conventional seeds in Europe from the perspective of those who must comply with the regulation – EU seed firms. Specifically, we first examine the operational changes that might be necessary for seed firms to comply with alternative AP thresholds for conventional seeds. Then, we analyze the associated market uncertainties, compliance costs and their implications on firm and industry competitiveness.

Introduction

Since settling on its mandatory labeling rules for genetically modified (GM) foods in the late 1990s, the European Commission has considered a number of times setting tolerance levels (thresholds) for the accidental presence of GM material in conventional seeds.1 In every case, it has opted to defer the decision.

In the absence of such thresholds, current European labeling laws require that seeds be labeled as GM if they contain any detectable trace of GMOs approved for cultivation in the EU.2 Conventional seeds with detectable traces of GMOs that have not been authorized for cultivation cannot be sold in the European market altogether.

A number of recent studies have indicated that preventing the adventitious presence of GM traces in conventional planting seeds is both difficult and expensive (Bock et al., 2002; European Commission, 2001; Kalaitzandonakes and Magnier, 2004; Messéan et al., 2006). And in line with such considerations, trace amounts of GM material have consistently turned up in conventional seed lots when those have been randomly tested (e.g. Central Science Laboratory, 2007; Mellon and Rissler, 2004; United States GAO, 2008). Despite these inherent market risks, the EU Commission has, so far, avoided bringing forward a proposal for specific AP thresholds in conventional planting seeds.3

As the acreage of GM crops has continued to grow at a fast pace around the world (James, 2012), calls for setting AP thresholds for conventional seeds in the EU have multiplied. Indeed, in recent years the European seed industry has actively lobbied the EU Commission for setting “practical” AP thresholds for seeds and has argued that in their absence the industry’s competitiveness is in question (European Seed Association, 2007; 2010).

1 Most mandatory GM labeling laws make explicit allowances for the presence of GM traces in non-GM foods since perfect segregation of GM and non-GM material in the agrifood supply chain is not easy to achieve in practice. Such allowances are set up as tolerances or purity thresholds which define the amount of GM material that triggers labeling of a food product as “GM”. Since the GM content allowed is generally meant to be “accidental and unavoidable”, these purity thresholds are often referred to as “adventitious presence”, or AP thresholds.

2 For a general discussion on the economics of AP thresholds of food products and their welfare implications (see Giannakas et al., 2011).

3 It should be noted that the EU is not alone in its lack of explicit AP policy for conventional seeds. In fact, only a handful of countries have set AP thresholds for conventional seeds. These include Argentina, Austria, Hungary, Italy, and Romania. Of these countries, only Argentina has any GM crop cultivation and hence, for the other countries, AP restrictions pertain only to maize seed imports.
On the face of it, these arguments seem odd. While the existing AP restrictions in conventional seeds might bring about market risks and impose compliance costs, it is unclear why they should burden disproportionately the European seed industry. If anything, the European seed industry would seem to be best positioned to benefit from the current AP restrictions as there is little GMO production in Europe to interfere with its seed production systems. Furthermore, lack of explicit AP standards would seem to protect the EU seed industry from import competition. So are AP thresholds for conventional seeds needed in the EU market? Is the competitiveness of the EU seed industry being affected by the current AP restrictions and the lack of explicit AP thresholds for seeds? If explicit AP thresholds for conventional seeds were to be set, what are “practical” ones?

In this paper, we seek to provide answers to these questions by examining the economics of alternative AP thresholds for conventional seeds in Europe. Specifically, we first examine the operational changes that might be necessary for European seed firms to comply with alternative AP thresholds in conventional seeds. Then, we analyze the associated market uncertainties, compliance costs and their implications on the industry’s competitiveness. To limit the scope of our study, we restrict our analysis to one type of seed: maize seed. Maize seed has the largest commercial value among all planting seeds and over the last 15 years it has provided a platform for the introduction of numerous GM traits around the world. Hence, the maize seed market is important in its own right and an excellent case study that can be generalized to other seed markets.

To meet our objectives, in Section ‘Firm operations and competitiveness in maize seed production’ we review the normal operations of maize seed firms and the key determinants of their competitiveness. In Section ‘Introduction of biotechnology and management of AP’, we discuss the various operational adjustments that can be used by maize seed firms to manage alternative AP thresholds. In Sections ‘Firm expectations for AP management and compliance costs’ and ‘Expected compliance costs and their structure’ we analyze the compliance costs associated with such operational changes and their underlying structure. Since there are few countries where AP thresholds for seeds exist, actual experience in managing seed production and trade under alternative AP thresholds is limited. For this reason, for our assessment we use two separate ex ante methodologies: (a) statistical analysis of firm expectations and (b) simulation of representative maize seed production systems in the EU. As we explain later in the paper, these methodologies are complementary in their reasoning, analytical approach, and findings. In Section ‘Operational changes and compliance costs in AP management: a simulation approach’, we synthesize the results and draw inferences about the relationship of AP regulation in conventional seeds and the competitiveness of the EU maize seed industry. Finally, in Section ‘AP restrictions and the competitiveness of the EU seed industry’ we offer some concluding comments.

Firm operations and competitiveness in maize seed production

To understand how compliance with alternative AP thresholds could change the operations of maize seed firms in Europe, one must first understand their standard operations. Biological constraints dictate that maize seed firms adopt long planning horizons as product development and commercialization are characterized by lengthy gestation lags (Fernandez-Cornejo, 2004). Maize hybrids are produced by crossing two unrelated inbred (parent) lines. Identical hybrids perform differently under different growing environments (e.g. soil fertility, climate, photoperiods, or elevation). Hence, the key objective of seed maize firms is to select combinations of inbred lines that yield hybrids well-adapted to the growing environments of target markets.

To this end, inbred lines must first be developed during breeding operations. Over successive generations, rigorous selection for maturity, height, plant color, vigor, pollen shed, seed yield, disease resistance, and other characteristics is carried out (Copeland and McDonald, 1995). It typically takes 3–5 years to produce a desirable inbred. Hybrids are next developed through a similarly prolonged process of successive experimentation and selection. In any given year, thousands of combinations of inbred lines are produced and evaluated in hundreds of locations around the world in order to ensure adequate adaptation to various growing environments. It typically takes a battery of tests and another 3–5 years to develop a single marketable hybrid.

Commercial production of the few hybrids that are selected to be sold to farmers in any given year requires large amounts of their parent lines to be crossed in seed production fields. Hence, following breeding, the selected parent lines must be scaled up to substantial volumes. The scaling up of inbred lines for new hybrids typically takes two growing seasons. The subsequent commercial production of the hybrid seeds is done through contracts with selected farmers who, in most cases, are clustered around seed processing plants. Production planning for hybrid seeds starts in the beginning of each year and is based upon sales projections for the following year—12–18 months ahead of receiving orders from farmers.

Through this lengthy process, firms seek to develop hybrids with desirable traits that match closely market needs—a key determinant of product quality in the maize seed industry. Another key determinant of product quality is seed purity. Seed purity is safeguarded from breeding to hybrid production through advanced quality control systems (Desai et al., 1997). Due to the large amounts of commercial hybrid seeds produced in open environments, control of purity is most challenging during this last stage of maize seed production.

To maximize yields and geographic adaptation, parent lines and hybrid seeds are grown in the most fertile maize-producing lands, typically, in the midst of maize grain production areas. High purity levels are secured by avoiding mechanical admixtures as well as natural outcrossing through substantial isolation distances between seed production fields and fields producing maize for grain. Every year, maize seed firms expend significant efforts to secure fields with desired isolation distances. Contract farmers cooperate with neighboring farmers and firm field managers to meet isolation requirements and establish planting schedules that minimize the probability of adventitious pollen intrusion in their fields.

Strict quality control systems must ensure that seed purity is maintained through seed processing and conditioning as well. As the ears of hybrid maize seed begin to dry down in the field, seed processing plants prepare for harvest. Different fields planted with the same hybrid are harvested and delivered to the plant together so that they can be processed as a single seed lot. Early harvest is preferable as hybrid seeds maintain their quality best when dried slowly and in a controlled environment in the plant. Early harvest also helps to avoid risks of frost injuries (Desai et al., 1997). For these reasons, after harvest begins seed processing plants operate 24 h a day and 7 days a week to facilitate timely harvest, delivery, and processing of hybrid seeds. Processing of harvested hybrids involves dehusking, sorting, drying, shelling, conditioning, sizing, treating and packaging. From the time hybrids are delivered and through each processing step, each seed lot is separately tracked inside the plant—usually through computerized systems.

Key competitiveness drivers

As seed firms seek to optimize the performance and market competitiveness of their hybrids at various growing environments,
they divide the overall seed market into increasingly smaller segments that must be supplied with larger numbers of hybrids (Magnier et al., 2010). This increases the number of parent lines, extends product development cycles and raises development and production costs. Importantly, it also increases the planning complexity for seed firms. Forecasts of market demand must inform breeding operations and commercial seed production years ahead of any actual product sales. Accurate market assessment for a multitude of markets and hybrids is inherently difficult. Since farmer demand for hybrids is affected by, among other factors, commodity prices, government programs, customer preferences and weather, demand forecasts can be inaccurate. As the number of hybrids marketed increases, so does the likelihood of forecast errors. Overestimation of demand for any hybrid results in excess inventories and higher levels of obsolescence and discards. Underestimation of demand results in foregone market opportunities. Both are costly to maize seed firms.

To increase the effectiveness of their product development programs and shorten development cycles, maize seed firms have, over time, internationalized their R&D and breeding operations. Today, most maize seed firms that develop their own genetics have numerous breeding stations around the world which allow experimentation with a broad germplasm base under diverse climatic and ecological conditions.

Traditional breeding program for major crops have progressively been supplemented by genomic-based technologies that have made crop selection and the introduction of novel traits much more efficient (Fischer and Edmeades, 2010). Marker assisted-selection (MAS) has led the way (Tester and Langridge, 2010) by using molecular markers (i.e., identifiable DNA sequences found at specific locations of the genome), to verify the inheritance of various genes after cultivars are crossed. This approach greatly increases the reliability and effectiveness of the subsequent selection process and it has significantly reduced the cost of running breeding programs. With the help of MAS technologies, the presence of genes of interest can indeed be verified in plants before they are fully grown thereby eliminating most of the costs associated laborious phenotypic selection and field trials (Hoisington and Listman, 1998). The development of related tools such as association mapping, marker-aided recurrent selection, bioinformatics, biometrics, robotics, and remote sensing has also greatly contributed to improve to the efficiency of breeding program and facilitate the introduction of new traits into conventional lines (Fischer and Edmeades, 2010).

To improve quality control, manage risk, contain costs, and accelerate commercialization maize seed firms have also internationalized their production and processing operations. Today, maize seed firms of even modest size scale up parent lines and produce and process hybrid seeds at multiple locations around the world, both in the North and in the South hemisphere. Use of multiple locations allows cost effective production and management of weather and other production risks. Similarly, use of counter-seasonal (North–South) production systems shorten seed production cycles as two or more growing seasons are fit within any given year and add to the ability of maize seed firms to respond to changing market conditions.

Introduction of biotechnology and management of AP

The introduction of crop biotechnology has created value added opportunities for seed firms through the introduction of GM traits (e.g. insect resistance, herbicide tolerance, improved oil, and protein profiles) (Phillips and McDougall, 2012). However, introduction of new GM traits has also led to a significantly larger number of hybrid seeds handled by seed firms and shorter time periods they stay in the market (Magnier et al., 2010). As such, integration of GM traits into the germplasm base has also increased the planning complexity in the seed industry.

In the presence of regulatory restrictions on the use of certain GM traits, conventional seeds must be kept free of these traits. Hence, depending on the regulatory allowances and their market demand for conventional seeds, maize seed firms must manage the AP of GM material in conventional seeds throughout their life cycles, from breeding to hybrid seed production and commercialization. This is a challenging task in a world of increasing market penetration of GM traits and asynchronous regulatory approvals at various markets. Nevertheless, since seed firms have advanced quality control systems in order to ensure the genetic purity of their hybrids, they would seem well-prepared to adapt their operations to handle AP in conventional seeds.

Seed firms could reengineer their breeding, production, processing and conditioning operations in order to reduce AP levels of GM material in conventional seed. But not all reengineering strategies are equally effective or costly. Some strategies substitute for one another, whereas others can be used jointly to increase effectiveness. Hence, depending on the AP thresholds set by regulators and the operational flexibility allowed by their assets maize seed firms could consider a mix of strategies to maximize AP control and minimize compliance costs.

As purity can only diminish in seed production and distribution, extremely high purity levels must be achieved at the initial breeding stage. Breeding is highly controlled and AP is less likely. Best management practices can be tightened, but the primary strategy for ensuring purity in breeding is exhaustive testing. Seed firms must test all inbred lines for various GM events and hence testing costs increase rapidly as the parent lines and traits under development increase in number.

Different reengineering strategies may also be adopted to limit AP in maize seed production from mechanical admixtures and the presence of volunteers or pollen intrusion in maize seed production fields. Controlling pollen intrusion is most challenging. Seed production is more susceptible to outcrossing from foreign pollen. Male inbred parent lines do not typically produce as much pollen relative to the amount of pollen produced by the male flower of hybrids. Seed production fields also contain only a few male flowers because the male flower of the female inbred parents are removed (detasseled) to avoid self-pollination of the female parent line (Angevin, 2008).

Limited amounts of pollen available from parent lines in the inbred seed production fields increase the chance of foreign pollen intrusion from adjacent fields. However, the generally narrow traveling distance and limited viability of maize pollen suggests that increased isolation distances between fields can reduce potential outcrossing with foreign pollen (Bateman, 1947; Burris, 2001; Ireland et al., 2006; Jones and Brooks, 1950; Luna et al., 2001; Ma et al., 2004). Higher isolation distances can be secured only at higher per-acre contract costs and, sometimes, at lower per-acre seed yields if land quality declines. Block planting, which consists of grouping seed production fields that use the same male pollinator to limit the intrusion of foreign pollen in the block, can also be used. Block planting reduces potential outcrossing but could encounter higher contracting costs for securing adjacent fields.

Changes in cultural practices may also reduce the probability of AP in maize seed production. For instance, increasing the number of rows of the male parent in a field’s outer border can reduce outcrossing (Burris, 2001; Copeland and McDonald, 1995; Ireland et al., 2006). In this way, foreign pollen is diluted by the pollen mass of the male parent. Increasing the number of male border rows is costly, however, because less hybrid seed is produced per unit of land (as only female plants produce seeds), and extra costs for the male seeds are incurred.
Careful time-isolation of inbred lines and hybrids from other surrounding maize production can also be effective (Halsey et al., 2005; Ma et al., 2004; Messeguer et al., 2006). Under time-isolation, inbreds and/or hybrids are planted later than other nearby maize in order to prevent cross pollination during the flowering and shedding periods. Seed firms may time-isolate only part of their production to limit frost risks from delayed harvest and avoid reductions in expected yields resulting from suboptimal growing season length. Seed firms might also shift the production of conventional parent lines or hybrids to areas where commercial cultivation of GM seeds or crops does not take place. Such movements can minimize AP but at the costs of suboptimal growing environments as well as longer transport distances and higher costs.

Various reengineering strategies can also be implemented at the processing and conditioning stage, although processing is already tightly controlled and less exposed to open environments. For instance, fields suspected of possible foreign pollen intrusion can be "flagged" and harvested separately. Aggressive flagging of fields can decrease the extent of AP by containing suspected lots at early processing stages but at increasing processing costs. As identical hybrids produced in different fields are less commingled, they lead to a larger number of lower volume lots, inefficient use of dryers, storage bins, and other plant assets, and ultimately, added processing costs.

Plant equipment is cleaned after each individual lot is processed, but the extra care in cleaning that may be needed under very low AP thresholds would prolong processing operations, increase plant inefficiencies, and add costs. Meticulous testing of all seed lots produced ensures that AP can be detected even at this late stage. Lots that do not meet target AP thresholds can be discard but only after production and processing costs have been incurred.

While seed firms have a number of reengineering options and the required experience in advanced quality control systems to implement them, a problematic aspect of such operational changes is that there is no practical way to eliminate the risk of AP. Maize seed firms can expend an increasing amount of resources to tighten their quality control systems and minimize AP but unless they can test every commercial seed kernel they cannot guarantee that their conventional seeds are "GM free”. Furthermore, assay uncertainty (type II error) in GM testing can compromise even the most well-executed quality control systems (Remund et al., 2001). Hence, AP thresholds that allow some low level of GM content and add flexibility in the production and marketing systems of maize firms and reduce their risk exposure. The higher the AP thresholds are the higher the operational flexibility of seed firms for managing AP and the lower their risk exposure is.

The question then is what kind of operational adjustments seed firms would need to implement under alternative AP thresholds to effectively meet regulatory restrictions while minimizing compliance costs and risks of failure? Are certain types of firms better or worse positioned to respond? Would, for instance, compliance costs and risks vary by firm size or location implying structural competitive disadvantages? To answer these questions, we developed and executed a web-based survey designed to gauge the expectations of maize seed firms located in different countries on their likely responses to alternative AP thresholds and associated compliance costs. We describe the results of the survey in the next section.

Firm expectations for AP management and compliance costs

Since AP thresholds for conventional maize seed have been set by regulators in only few countries, firms have had limited experience in dealing with them. Indeed, most of the practical experience that maize seed firms have had so far appears to be with ensuring that conventional seeds directed to certain markets with implicit or explicit AP thresholds set at detection do not contain any traces of GM material. Hence, firm or market-level data on the relationship of alternative AP thresholds and the reengineering of seed operations or the associated compliance costs does not exist. For this reason, we began our analysis by measuring the expected operational changes and compliance costs under alternative AP thresholds by soliciting the opinions of those who know the operational realities of the maize seed industry best: supply chain managers in various maize seed firms.

To identify an appropriate sample, we contacted the American Seed Trade Association and the International Seed Trade Federation who provided contact information for the directors/vice presidents of supply chain operations in all of their member firms with maize seed sales. For firms that did not have such a role in their executive staff, the Chief Operating Officer or the CEO was selected as the contact person. A total of 283 executives in maize seed firms around the world were identified through this process and were included in the sample. We then contacted all individuals in the sample via email and invited them to participate in a web survey with 15 questions. 68 of the individuals whose firms were engaged in breeding, production, and/or processing and conditioning of maize seeds completed the survey (a 24% return rate).

It should be noted that this is a high effective response rate, much higher than the 24% rate recorded above would indicate. While there is a large number of maize seed firms that sells hybrids in various markets around the world, only a subset of those actually produce and process their own hybrids and an even smaller subset develops proprietary parent lines and hybrids. Many of the small maize seed firms purchase their hybrids from a handful of foundation seed firms and toll manufacturers under “private label” arrangements. Since maize seed firms rarely reveal such arrangements, it was upfront unclear how many of the firms we contacted were, in fact, actively engaged in breeding, production, and/or processing and could answer our questions.

A profile of the maize seed firms whose executives completed the survey is presented in Table 1. Almost half the respondents were located in North America (US and Canada), another 20% in Europe while the rest in South America (Argentina, Chile, and Brazil) and other countries. 45 firms had their own breeding programs and 18 of them sold foundation seed to other maize seed firms. Out of a total of 50 firms that produced commercial hybrid seeds in the sample, 11 firms toll-manufactured seeds under private label arrangements. 44 of the firms were involved in exports and 36 in imports of maize seeds. Most of such import/export activity involved intra-firm transfers.

Expected compliance costs and their structure

Our survey focus was on the size of the expected compliance costs associated with various AP thresholds. Since seed firms guard production costs carefully, to maximize the likelihood of response we posed questions on the expected compliance costs in terms of

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Since much of the conventional maize seed sold in countries with “practical zero” AP thresholds is produced locally or in other non-GM regions, most firms transacting in these markets have focused their efforts on testing exhaustively the limited amounts of conventional seeds imported from countries with GM maize production (e.g., the US and Argentina) or GM seed production (e.g., Chile). Expecting that “skim” their conventional maize seed inventories at the point of export in order to identity lots free of GM traces. As the amounts of maize seed traded have historically only been a small share of the total conventional maize seed produced, this approach has proven adequate while imposing limited compliance (mostly testing) on maize seed firms. With the increase in GM maize production, conventional seed production and inventories have continued to decrease and, as a result, this approach has become impractical in recent years.
percent increases over base. Specifically, we asked the respondents to estimate the incremental costs in their production operations for a selected set of alternative AP thresholds: 2%, 1%, 0.5%, and 0.3% of GM content. Average expected compliance costs by region and threshold are reported in Table 2.

On average and across all regions, maize seed firms expected the compliance costs associated with the lower AP thresholds to be significant: 14.8% and almost 30% for 0.5% and 0.3% AP thresholds respectively. While we did not ask firms to report any other cost information, our own estimates indicate that production costs represent 30–45% of the retail selling price of a bag of seed. Accordingly, compliance costs could impact the overall costs and prices of hybrid seeds in a meaningful way.

Average expected compliance costs were somewhat lower among South and North American firms and higher among firms in the EU and the ROW. The variance of the expected compliance costs, however, was high across all regions and for the whole sample. For instance, expected compliance costs for the whole sample and for the 0.3% AP threshold varied from a low of 15% to a high of 100%. Such variance suggests that either the respondents were somewhat unsure about the potential compliance costs of alternative AP thresholds or that the impacts of AP restrictions could vary drastically across firms.

A question of interest in this study is whether there are structural differences in the expected compliance costs associated with different AP thresholds across maize seed firms. From those firms whose executives responded to the survey some were exclusively involved in breeding and parent line production while eight others did not supply complete compliance cost estimates. Hence only a subset of the firms had active breeding and production programs—42 firms in all—provided complete data amenable to statistical analysis. This data, along with a simple cost model we present next, allowed us to examine the structure of the expected compliance costs associated with the production of a given portfolio of hybrids. Such quasi-fixed factors of production could be changed in the short run (e.g. isolation distances and number of border rows used in the production of a given portfolio of hybrids). Such quasi-fixed factors can also be viewed as short term operational constraints for maize seed firms. Implicit in such a function is the homogeneity of output, which is assumed.

We also allow the production costs of the maize seed firms to be re-specified as

\[ c(y, w, z, Th) \]

For a given set of competitive input prices, we then specify the following empirical cost function:

\[ \ln C = c_0 + c_1y + c_2Th + c_3yTh + \frac{1}{2}c_4Th^2 + c_5z + c_6zTh. \]

which suggests that

\[ \frac{\partial \ln C}{\partial Th} = d_0 + c_1y + c_2Th + c_6z. \]

Hence, the percentage change in production costs from a unit change in the AP threshold is a linear function of \( y, z \) and \( Th \). Accordingly, compliance costs are allowed to vary with the level of AP, with the degree of operational flexibility of maize seed firms, and with the level of output size.

Relevant data for the estimation of the compliance cost function above is available from the survey. The dependent variable is measured as the percentage change in the firm’s production costs due to a change in the AP threshold. Because we only have a limited number of AP thresholds for which cost expectations were solicited, we specify those as separate dummy variables where \( Th_1 = 1 \) when AP = 0.3%, 0 otherwise; \( Th_2 = 1 \) when AP = 0.5%, 0 otherwise; \( Th_3 = 1 \) when AP = 1%, 0 otherwise. The threshold level against which the other threshold are compared is the one for which AP = 2%.

Firm operational flexibility is measured by the ease that the level of certain quasi fixed factors of production could be changed in the short run. These indicators included: the percent of production for which field isolation could be doubled (\( I \)); the percent of production for which the number of borders rows could be doubled (\( B \)); the percent of production for which the number of weeks of time isolation could be doubled (\( T \)); and the percent of production that could be moved to another location where outcrossing from GM maize would not be a problem (\( R \)). The above operational flexibility indicators are categorical in nature. For example, \( T \) takes a value of 1 if 0–25% of the production is grown on fields whose time isolation could be doubled; 2 if 25–50% of the production was grown on such fields; and so on.

The location of each seed firm in the sample was included to account for any relevant structural differences in the production capabilities of different geographic regions. If the firm was located in the EU, the variable EU takes of value of 1 and 0 otherwise while if the firm is located in South America or the rest of the world, the variable ROW takes of value of 1 and 0 otherwise. The intercept of the regression refers to firms located in North America.

Output level (firm size) was similarly included in the regression through relevant dummy variables. For small firms with output between 50,000 and 250,000 units (bags) per year \( S \) takes the value of 1 and zero otherwise. For medium size firms with output between 250,000 and 1,000,000 units per year the variable \( M \) takes the value of 1 and zero otherwise. For large firms with output that exceeded 1,000,000 units per year, the variable \( L \) takes the value of 1 and zero otherwise. Very small maize seed firms with output of less than 50,000 units per year were subsumed in the intercept.

Table 1

<table>
<thead>
<tr>
<th>Region</th>
<th>Activities of firm involvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>Development of proprietary genetics, Production of parent seed, Production of parent commercial seed, Toll manufacturing, Sales of foundation seed, Sales of commercial seed, Exports of seeds, Imports of seeds</td>
</tr>
<tr>
<td>North America</td>
<td>9, 7, 8, 1, 5, 11, 9, 11</td>
</tr>
<tr>
<td>South America</td>
<td>4, 5, 5</td>
</tr>
<tr>
<td>Rest of the world</td>
<td>7, 7, 7</td>
</tr>
<tr>
<td>(ROW)</td>
<td>7, 7, 7</td>
</tr>
<tr>
<td>All (total)</td>
<td>45, 44, 50</td>
</tr>
</tbody>
</table>

For a given set of competitive input prices, we then specify the following empirical cost function:

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The empirical specification of the compliance cost function above is then

\[
\frac{\partial \ln C}{\partial \text{Th}} = a_0 + a_1 \text{Th}_1 + a_2 \text{Th}_2 + a_3 \text{Th}_3 + a_4 \text{S} + a_5 \text{B} + a_6 T + a_7 R + a_8 \text{EU} + a_9 \text{ROW} + a_{10} S + a_{11} M + a_{12} L.
\]

This empirical equation was first estimated through an Ordinary Least Squares regression. Because White’s and Breusch–Pagan tests indicated the possibility of heteroskedasticity at a 10% significance level, we used White’s corrective method and the parameter estimates from the non-linear OLS regression are reported in Table 3. The overall statistical fit of the regression model is satisfactory as indicated by the R square and F statistic.

The results indicate that the compliance costs anticipated by seed firms are significant and increase non-linearly as AP thresholds become smaller. More specifically, for a 1% AP threshold seed firms expect they would spend, on average, 4% more to produce a bag of maize seed. The rate of increase speeds up, however, as AP thresholds diminish resulting in an almost 12% increase in the expected unit costs for a 0.5% AP threshold and a 25% increase for a 0.3% AP threshold. Because the rate of change is found to increase as AP threshold gets lower they suggests a non-linear relationship between AP thresholds and the production costs of maize seed firms. This result is consistent with the non-linearities in the relationship of AP thresholds and firm costs identified in Kalaitzandonakes and Magnier (2004) and suggests that maize seed firms expect to expend resources at an increasing rate as AP thresholds diminish.

Among the indicators that measure the degree of a firm’s short term operational flexibility only one is found to have a statistically significant impact on expected compliance costs: production relocation (R). In this context, if a firm could move up to 25% of the firm’s production to a location where AP is not a problem, compliance costs are expected to diminish by almost 8%.

No significant differences could be identified in the expected structure of compliance costs and AP thresholds of North America and EU seed firms. Firms in the ROW, however, expected to incur higher than average compliance cost as AP thresholds diminish.

An interesting and rather unexpected result in the regression indicates that medium size seed firms could be disadvantaged as they expect to incur, on average, 11.25% higher compliance costs in their production relative to both large and small firms for the same AP thresholds. We reason that small firms might be relatively less exposed to incremental AP costs due to the typical ownership of their production fields and limited number of hybrids and volume to manage. Similarly, larger firms might be less exposed due to their flexibility of managing AP through a portfolio of facilities and production locations and advanced quality control systems. Medium size firms appear to have a large number of hybrids as they sell in multiple markets but operate fewer processing facilities and hence have a more limited portfolio of assets to manage AP restrictions. This result suggests that structural impacts from AP regulation in the maize industry may be possible.

### Operational changes and compliance costs in AP management: A simulation approach

While the results of the firm survey and regression analysis are interesting and informative, they also demonstrate the inherent difficulties in analyzing the relationship of operational adjustments, compliance costs and AP thresholds through such an approach. Simply put, there is too much complexity in the system to be delineated through a survey. The universe of maize seed firms engaged in breeding, production and processing operations is not very large. Each of these firms is distinct in operations and business model. Some engage only in breeding; others only in toll manufacturing; some are fully integrated developing and commercializing only their own germplasm and hybrids; yet others outsource a portion of their breeding and/or production operations. Similarly, most of these firms have operations in various production regions and operate both small and large plants. These conditions make it difficult to draw complete data on the structure of compliance mechanisms and costs through a brief and standardized survey instrument. Furthermore, the small number of these firms limits the strength of any statistical analysis from such data.

Because of these inherent complexities, we elected to further our analysis using Monte Carlo simulation which allows more in depth examination of the mechanisms by which alternative AP thresholds could impact the operations and compliance costs of European maize seed firms. This approach has been used for the analysis of reengineering strategies in the US seed industry (Kalaitzandonakes and Magnier, 2004) and for other traceable parts of the agrifood supply chain with reasonable success (Kalaitzandonakes et al., 2001; Wilson and Dahl, 2006). Here we use the same modeling platform employed by Kalaitzandonakes and Magnier, called PRESIP-SEED, appropriately adapted to characterize representative maize production systems in the EU.

### Methodology

PRESIP-SEED includes both engineering and economic simulation modules and it is capable of representing the physical layout and workings of maize seed production systems in great detail. Because of its structure PRESIP-SEED can isolate even minute impacts from changes in operations, management practices and physical assets on the inputs, output, efficiency and costs of maize seed production (e.g. changes in the hours of operation of a dryer in a seed processing plant). And because it is transparent, it can disaggregate the individual sources of any measured impacts. The model is particularly useful for ex ante analysis of reengineering practices that have not been implemented in practice and for which historical data is not available. Hence, it is well-suited for examining the

<table>
<thead>
<tr>
<th>Threshold</th>
<th>Expected change in production costs – % change relative to base</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2%</td>
</tr>
<tr>
<td>European Union</td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td>SD</td>
</tr>
<tr>
<td>North America</td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td>SD</td>
</tr>
<tr>
<td>South America</td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td>SD</td>
</tr>
<tr>
<td>Rest of the World</td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td>SD</td>
</tr>
</tbody>
</table>

Table 2: Average expected compliance costs by region and AP threshold.
The pace at which GM adoption could proceed is still unclear because in Europe already exists (Gómez-Barbero et al., 2008; James, 2012), could be reengineered in the future to comply with AP threshold study and in order to analyze how European maize seed operations analysis.

changes and compliance costs in European maize seed production. The relationship of alternative AP thresholds and related operational changes and compliance costs in European maize seed production. The basic workings and structure of PRESIP-SEED are detailed in Magnier and Kalaitzandonakes (2013). Through the model, the physical asset configuration, operations and management of representative maize seed production systems that can comply with selected AP thresholds at minimum costs are first identified and then compared to relevant baselines which mimic normal operations for these production systems. When reengineering leads to increased unit costs against baseline operations, the cost differentials are counted as compliance costs. Therefore, for PRESIP-SEED to be effective, appropriate representative maize seed production systems must be carefully selected and their normal operations must be effectively modeled to provide accurate baselines for all scenario comparisons. For this purpose, cooperation from maize seed firms that can contribute detailed production, processing, and operational data to calibrate the model is necessary.

Three leading European maize seed firms, Limagrain and RAGT from France and KWS from Germany, accepted to participate in the study and contribute confidential data. Three different production regions and processing plants—two in France and one in Germany—were selected as typical of European maize seed production. Together, these three production systems included over 3500 seed production fields with a total production area of over 10,000 hectares and processing capacity of almost 2 million bags of maize seeds.

Baseline development and scenario implementation

In the absence of GM production, maize seed production systems in Europe, like those selected for our study in France and Germany, had not had to adapt their operations to meet AP thresholds. They simply have had to ensure that the parent lines used in hybrid seed production are free of any GM content. For the purpose of our study and in order to analyze how European maize seed operations could be reengineered in the future to comply with AP threshold restrictions, we assumed coexistence. While GM maize production in Europe already exists (Gómez-Barbero et al., 2008; James, 2012), the pace at which GM adoption could proceed is still unclear because of uncertainties associated with regulatory approvals of GM crops (Abbott and Schiermeier, 2007), the stringency of the coexistence measures and country bans on GM crops (Beckmann et al., 2006; Demont and Devos, 2008). For our analysis we assumed a 25% GM (seed and grain) maize adoption in the areas of the representative maize seed production systems. We then examined what type of reengineering strategies would be relevant for such conditions and what compliance costs might be incurred under alternative AP thresholds. Four AP thresholds were selected for the analysis due to their relevance to the ongoing discussion of regulatory options in the EU: 1%, 0.5%, 0.3% and 0.1%

Given these assumptions, we began our analysis by constructing detailed baseline models for the selected representative maize seed production systems. Data provided by the collaborating firms was used to calibrate the simulation model to mimic the field and plant operations of each of the representative systems. Baseline models were considered complete only when throughput statistics for different operations (planting, harvesting, drying, storing, and processing) averaged over across a large number of model replications closely resembled historical throughput data and timelines for each separate production system.

After the baseline models were completed, plant managers provided data and information which was used to quantify the flexibility of each of the representative production systems in making relevant operational adjustments (e.g. percentage of land for which isolation could be increased by various distances, number of hybrids that would be time isolated and so on). For the purpose of this analysis, the only source of AP in maize seed production fields was assumed to be from pollen outcrossing. Admixtures from volunteer plants, remaining GM seeds in field and plant equipment and other sources were assumed to be zero.

The final step of the analysis involved identification of feasible operational adjustments that could meet the selected AP thresholds. For each AP threshold, various reengineering scenarios were simulated based on feasible adjustments in each of the production system and processing location analyzed. Simulated reengineering scenarios that could meet the selected AP thresholds were maintained and associated throughput and cost results were further analyzed. Simulated reengineering scenarios that could not meet the selected AP thresholds were discarded. To account for stochasticity, 30 replications of each baseline model and reengineering scenario were run.

Results

The estimated compliance costs per unit of maize hybrid seed and their underlying structure are presented in Table 4. The results indicate that compliance costs are significant and increase non-linearly as AP thresholds become smaller. Hence, the simulation results are consistent with those from the regression analysis in the previous section, though the calculated compliance costs here are somewhat higher than the global average estimated econometrically above. More specifically, we estimate that under conditions of coexistence and for a 1% AP threshold, European firms would spend, on average, 6.8% more to produce a bag of maize seed. The rate of increase speeds up, however, as AP thresholds diminish resulting in a 28% increase in unit costs for a 0.5% AP threshold, a 35% increase for a 0.3% AP threshold and a 68% jump for a 0.1% threshold. By comparison, the changes in production costs that we obtained through the econometric model were 4.0%, 11.8% and 24.93% for 1%, 0.5% and 0.3% AP thresholds respectively. It is worth noting that the standard deviations for all such average

Table 3

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Error</th>
<th>t Value</th>
<th>Pr &gt;</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>4.076</td>
<td>3.880</td>
<td>1.050</td>
<td>0.296</td>
<td></td>
</tr>
<tr>
<td>Th = 0.3</td>
<td>24.938</td>
<td>2.968</td>
<td>8.400</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Th = 0.5</td>
<td>11.842</td>
<td>1.675</td>
<td>7.070</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Th = 1.0</td>
<td>4.035</td>
<td>1.579</td>
<td>2.550</td>
<td>0.012</td>
<td></td>
</tr>
<tr>
<td>l (isolation distance)</td>
<td>2.172</td>
<td>1.486</td>
<td>1.460</td>
<td>0.147</td>
<td></td>
</tr>
<tr>
<td>B (border rows)</td>
<td>5.365</td>
<td>3.574</td>
<td>1.500</td>
<td>0.137</td>
<td></td>
</tr>
<tr>
<td>T (time isolation)</td>
<td>1.678</td>
<td>1.281</td>
<td>1.310</td>
<td>0.193</td>
<td></td>
</tr>
<tr>
<td>R (relocate production)</td>
<td>7.785</td>
<td>1.670</td>
<td>4.660</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>EU (European Union)</td>
<td>-0.648</td>
<td>1.550</td>
<td>0.420</td>
<td>0.677</td>
<td></td>
</tr>
<tr>
<td>ROW (Rest of World)</td>
<td>7.583</td>
<td>1.902</td>
<td>3.990</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Small size</td>
<td>1.251</td>
<td>1.962</td>
<td>0.640</td>
<td>0.525</td>
<td></td>
</tr>
<tr>
<td>Medium size</td>
<td>11.255</td>
<td>4.279</td>
<td>2.630</td>
<td>0.010</td>
<td></td>
</tr>
<tr>
<td>Large size</td>
<td>0.726</td>
<td>1.767</td>
<td>0.410</td>
<td>0.682</td>
<td></td>
</tr>
<tr>
<td>R-square</td>
<td>0.637</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adj-R2-Sq</td>
<td>0.589</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F-value</td>
<td>13.28</td>
<td></td>
<td>&lt;0.001</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5 Limited adoption of GM maize for grain production took place in both France and Germany until 2008 when production stopped as a result of national bans (USDA-FAS, 2010). However, the amount of land devoted to such cultivation was limited and away from any maize seed production in these countries. Hence, maize seed production for the representative systems analyzed here has, so far, not occurred under coexistence.

6 Note, however, that the estimated compliance costs from the simulation model are similar to the compliance costs reported by European seed firms in our survey (reported in Table 2).
incremental costs are rather small suggesting limited variation around the reported means across all representative production systems. In effect, all selected production systems experience significant incremental compliance costs. At 0.1% AP threshold only two of the three representative production systems continue to operate, though at an average 68% higher unit costs. The third plant confronts binding constraints in both field production (e.g. it cannot secure sufficient field isolation) and processing and as a result it ceases such operations at its current location.

For comparison purposes, in Table 4 we have also listed the estimated compliance costs for US maize seed firms reported in Kalaitzandonakes and Magnier (2004). On a percentage basis, compliance costs are similar in Europe and in the US. What is not apparent from the results reported in the table, however, is that compliance costs for EU maize seed firms are significantly higher on an absolute value basis.8 With an average field size a tenth of that in the US, almost 8 times as many fields to plant and harvest, and a larger number of smaller volume seed lots to process, maize seed firms face almost 30% higher unit costs in Europe than in the US. Higher compliance costs from AP restrictions could therefore widen this gap.

Incremental field costs represent initially the largest share of the compliance costs in the selected EU maize seed production systems—71% for 0.5% AP threshold and 58% for 0.3%. The share of additional processing costs, however, increases as AP thresholds become lower—from 18% for 0.5% AP threshold to 40% for 0.1%. Increasing processing costs are the result of growing inefficiencies in the plant due to the reduction of lot size which extends the time of plant use for processing and conditioning. Hence, as AP thresholds diminish, capacity constraints in the representative plants become more binding. This result is different from that obtain by Kalaitzandonakes and Magnier (2004). The reason appears to be that the capacity constraint seems more binding in EU plants and they process a much larger number of smaller lots. Testing costs, often assumed to be a primary source of compliance costs in managing AP represent only a modest portion of cost increments—10% or less for all AP thresholds.

A key source of AP compliance costs that is not separated out in Table 4 is the discard of non-compliant maize seeds. Discards increase in size as AP thresholds become progressively lower and raise unit costs as production and processing costs are fully born while saleable output is reduced. More specifically, seed discards vary from a low of 8% to a high of 35% between 0.5% and 0.1% AP thresholds for those plants that continue to operate.9 The fact that discards continue to increase as AP thresholds diminish even as maize seed firms spend more to manage adventitious presence explains in large part the non-linear nature of AP compliance costs. They also point to an important issue that it is too often overlooked and which is at the heart of the debate of what a “practical” AP threshold might be. From a maize seed firm perspective, the “functional” AP thresholds that must be achieved in order to consistently comply with AP restrictions are different and much lower than those set by the regulators. Since AP is stochastic in nature and non-compliance is costly, firms must achieve average AP content in their production well below the threshold and AP distributions that are as skewed to the left as possible in order to minimize the likelihood of failure. As AP regulatory standards approach “practical zero” such task becomes increasing difficult and costly.

Model validation

A number of indicators corroborate the reliability and validity of the empirical results derived from the Monte Carlo simulation. First, the constructed model is able to closely match a complex set of input–output statistics, throughput statistics for various pieces of equipment and operational timelines in selected representative maize seed production systems for which detailed data is available from the collaborating seed firms. Second, the empirical results of the model are stable and internally consistent across firms, production regions, and plant sizes. Third, the results of the simulation model are structurally consistent with those of the regression analysis, even though somewhat larger in size. While such indicators are encouraging, model validation can be strengthened if the empirical results can be shown to be consistent with market evidence. If, in fact, compliance costs were as significant as projected by the model, maize seed firms would be expected to respond proportionally. Since maize seed production in Europe under conditions of coexistence does not exist, potential firm responses are still unobserved. However, market data does exist on maize seed trade where seed firms have had to confront the reality of producing seed in some countries under conditions of coexistence and transferring them to countries with AP restrictions where seeds must be sold. Since the majority of such imports and exports are intra-firm transfers, one would expect to see firms respond to AP risk and compliance costs and, over time, shift the composition of trade.

Following this argument, if AP compliance costs are high one would expect to see the trade position of the US, the largest producer and exporter of maize seed in the world, change after the introduction of the first GM hybrid in 1996, especially in countries that rigorously enforce strict AP thresholds. While inventory “skimming” provided a partial and inexpensive solution for Table 4 Structure of compliance costs for selected AP thresholds: Evidence from simulation.4

<table>
<thead>
<tr>
<th>AP thresholds</th>
<th>1.0%</th>
<th>0.5%</th>
<th>0.3%</th>
<th>0.1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sources of AP compliance costs in the EU</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field costs</td>
<td>0.0%</td>
<td>20.0%</td>
<td>20.4%</td>
<td>33.0%</td>
</tr>
<tr>
<td>Plant costs</td>
<td>6.5%</td>
<td>5.1%</td>
<td>12.2%</td>
<td>27.5%</td>
</tr>
<tr>
<td>Testing costs</td>
<td>0.3%</td>
<td>2.9%</td>
<td>2.4%</td>
<td>7.4%</td>
</tr>
<tr>
<td>Total compliance costs per bag</td>
<td>6.8%</td>
<td>28.0%</td>
<td>35.0%</td>
<td>68.0%</td>
</tr>
<tr>
<td>SD</td>
<td>1.9%</td>
<td>3.1%</td>
<td>3.6%</td>
<td>8.1%</td>
</tr>
<tr>
<td>Min</td>
<td>3.5%</td>
<td>21.5%</td>
<td>26.6%</td>
<td>51.6%</td>
</tr>
<tr>
<td>Max</td>
<td>12.3%</td>
<td>34.3%</td>
<td>42.3%</td>
<td>81.1%</td>
</tr>
<tr>
<td>Sources of AP compliance costs in the US</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field costs</td>
<td>6.3%</td>
<td>19.4%</td>
<td>28.0%</td>
<td>NA</td>
</tr>
<tr>
<td>Processing costs</td>
<td>2.1%</td>
<td>5.7%</td>
<td>5.6%</td>
<td>NA</td>
</tr>
<tr>
<td>Testing costs</td>
<td>0.7%</td>
<td>1.7%</td>
<td>1.7%</td>
<td>NA</td>
</tr>
<tr>
<td>Total compliance costs per bag</td>
<td>9.1%</td>
<td>26.8%</td>
<td>35.3%</td>
<td>NA</td>
</tr>
<tr>
<td>SD</td>
<td>2.5%</td>
<td>5.4%</td>
<td>5.5%</td>
<td>NA</td>
</tr>
<tr>
<td>Min</td>
<td>5.3%</td>
<td>18.2%</td>
<td>24.6%</td>
<td>NA</td>
</tr>
<tr>
<td>Max</td>
<td>14.9%</td>
<td>39.6%</td>
<td>47.4%</td>
<td>NA</td>
</tr>
</tbody>
</table>

4 Figures for US maize seed firms are taken from Kalaitzandonakes and Magnier (2004).
exporting firms in the US during the first few years after the introduction of GM maize, if the model projections are in fact valid, the market share of US maize seed exports in countries with strict AP restrictions should be diminishing as GM maize adoption has continued to expand over time.

Fig. 1 illustrates the share of US maize seed exports in the four largest EU markets—France, Germany, Spain and Italy. Consistent with model projections, US exports have continued to diminish over time following the introduction of GM maize in the US. It is interesting to note, that the decline has been faster in Italy where enforcement has been most rigorous through the prosecution of firm executives. Indeed, maize seed exports from the US to Italy valued at 50 million euros per year evaporated within a 3 year period. We therefore conclude that the empirical results of the simulation model are consistent with the limited market data that it is currently available.

AP restrictions and the competitiveness of the EU seed industry

So what might we infer about the impacts of the EU AP restrictions on the competitiveness of the European maize seed industry? Our analysis suggests that in the future, and under conditions of coexistence, compliance with AP restrictions could imply significant incremental costs especially for low AP thresholds. Furthermore, such incremental costs would likely worsen the cost competitiveness of maize seed production in the EU. Is the European maize seed industry then anticipating such effects and can this explain why it has become increasingly vocal in its request to the EU Commission for “practical” AP thresholds? While this is possible, there are some additional and more immediate market pressures that might better explain the apparent apprehension of European firms about the influence of AP restrictions on their competitive position.

In the short term and in the absence of any significant GM production in Europe, compliance costs and risks for managing AP in European maize seed production should remain low. However, this is only part of the story. For all the European maize seed firms that operate breeding and, especially, parent line and commercial seed production in other parts of the world where GM crops are grown, the operating reality is that they must consistently achieve GM-free seed production under conditions of coexistence in the various countries where they breed and multiply seeds for the EU market. That is, they must manage to secure 0% AP for all their counter-seasonal production in countries where GM seeds are produced (e.g. Chile) or where both GM seeds and grain are grown (e.g. Argentina and South Africa). Our results above indicate this is both difficult and costly. Of course, counter-seasonal production of parent lines and hybrids is only a small portion of the total maize seed production for most firms and hence any incremental costs, however high, would likely be manageable. The risks of no-compliance though are not. Every lot with accidental presence of GM traces is simply scaled up in the next production cycle. Hence, the compliance costs of such errors can be very large (i.e. discards, loss of sales, market share loss and damage, etc.). As the global adoption of GM maize has continued to increase, the risks of such errors have continue to expand for all maize seed firms since their breeding and production operations are themselves global.

While these AP compliance costs and risks are more immediate, this would still seem to leave European firms no worse off than
other maize seed firms that have to compete in the EU market. They too would have to manage GM free maize seed production for their European hybrids. A closer look at the market position of various maize seed firms, however, reveals market conditions that place a disproportional economic burden on European firms.

In Table 5 we report estimated market shares for the 2006–2010 period and for the top firms in all key maize seed markets. Together, these markets account for more than 90% of the total global value of the sector. Simple inspection suggests that with the exception of Syngenta all other European maize seed firms (i.e. Limagrain, RAGT, KWS, Maisadour, Euralis, etc.) are relatively large players in the EU market but almost inconsequential in all others. Therefore AP compliance costs and risks apply directly to most of their production and cost base. In contrast, US-based global maize seed firms, like DuPont/Pioneer and Monsanto, have a much smaller portion of their production and cost base exposed to AP compliance costs and risks. While in the EU market they must comply with current AP restrictions, in other markets they operate with more liberal (e.g. Argentina) or no AP restrictions (e.g. US). Furthermore, because of their global production resources and the large volumes of seeds they sell, they can manage AP restrictions more effectively by optimizing hybrid production through a portfolio of production systems and locations and exports/imports by testing and “skimming” inventories, selecting for compliant lots.

Interestingly, while European maize seed firms are experiencing a deteriorating cost position due to AP restrictions, they are also facing diminishing revenue opportunities as they are unable to participate in the commercialization of GM traits that are fueling the profitability of seed firms in the US, South America and other countries (Phillips and McDougall, 2012). We therefore conclude that due to the global nature of maize seed breeding and production and the current structure of the global maize seed market, AP restrictions in the EU are placing the European maize seed industry at a competitive disadvantage. Such conditions will continue to worsen as GM adoption continues to expand around the globe.

These results provide an explanation for the recent active lobbying of the EU Commission by the European seed industry for setting “practical” AP thresholds for seeds. They also provide a potential rationalization for the result in our regression analysis that found medium size firms to expect disproportional compliance costs from AP restrictions.

Concluding comments

We have presented evidence from detailed analyses of representative maize seed production systems in Europe and a global survey of seed firms on the expected operating changes and associated compliance costs under alternative AP thresholds in maize hybrid seeds. Our empirical results suggest that under conditions of coexistence compliance with AP restrictions requires re-engineering of the normal operations of maize seed firms and significant compliance costs, especially for low AP thresholds. Indeed compliance costs increase non-linearly as AP thresholds diminish, a combined effect of increasing expenditures in field production, processing and testing and rising discards of non-compliant product.

AP costs and risks are not immediate in the production of maize seed inside Europe as cultivation of GM crops is still minimal. However, the risks and costs of current AP restrictions in the EU continue to grow for all seed firms with sales in the European market as they make use of a global breeding and production infrastructure which increasingly operates under conditions of coexistence. As the introduction of new GM events and traits continues to expand and the number of GM acres continues to grow worldwide, AP risks and compliance costs will also continue to escalate further eroding the competitive position of the European seed industry which is broadly exposed to them.

In recent years, the EU Commission has recognized that the regulatory environment in Europe can be complex and has taken steps to improve its regulatory efficiency (Commission of European Communities, 2002; European Commission, 2010). Its “Better Regulation” campaign is a broad strategy that intends to rewrite and repeal laws, redraft pending legislation and require economic and environmental impact assessments in order to advance industry competitiveness and innovation. Along the same lines, the European Commission recommends that coexistence measures should be proportional in the sense that they should not impose disproportionate impediment on farmers, seed producers, and other actors associated with any type of production (European Commission, 2003; Demont and Devos, 2008; Demont et al., 2009). Yet, in the absence of specific AP thresholds for seeds, the current GM labeling laws imply that AP restrictions induce significant and growing compliance costs and risks, eroding the competitiveness of the EU seed industry and could lead to further consolidation in the sector. Hence, the rules for AP thresholds in the EU seed market could provide a case study for practical implementation of the Commission’s Better Regulation policy.

References


