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# Attitudes toward GM foods, biotechnology R&D investment and lobbying activities among agribusiness firms in the food, feed, chemical and seed industries in China

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## Abstract

**Purpose** – Economic interest groups such as seed, pesticide, feed, and food companies play an important role in supporting or preventing the production of genetically modified (GM) crops. The purpose of this paper is to examine firm managers' attitudes toward GM technology, biotechnology R&D investment, and political lobbying activities.

**Design/methodology/approach** – Using data from surveys of 160 managers in the food, feed, chemical, and seed industries in 2013-2014, this paper employed three probit models to examine the determinants of managers' attitudes, biotechnology R&D investment, and lobbying activities.

**Findings** – The results show that most Chinese agribusiness managers are concerned about GM foods and oppose its adoption. Nevertheless, one-third of the firms invest in biotechnology R&D and less than 15 percent of managers lobbied the government to change biotechnology policies. The econometric estimation results suggest that profit change expectation is the main factor affecting managers' attitudes and biotechnology R&D investment decisions, whereas lobbying activities are significantly influenced by their attitudes and biotechnology R&D investment. In addition, managers' attitudes toward GM foods also significantly influence firms' decisions to invest in biotechnology R&D.

**Originality/value** – This paper has improved on previous research in two ways. First, it analyses the determinants of agribusiness firm managers' attitudes toward GM technology, biotechnology R&D investment, and lobbying activities. Second, the methodology involves an analysis of agribusiness firm survey data in the food, feed, chemical, and seed industries, which is the first time to use such data to research on economic interest group in agricultural biotechnology field.

**Keywords** China, Attitude, Agribusiness firms, Biotechnology R&D investment, GM crops, Lobbying activities

**Paper type** Research paper



## 1. Introduction

Since the introduction of genetically modified (GM) crops in 1996, the biotechnology industry has expanded rapidly. Global cumulative planting areas reached 2 billion hectares from 1996 to 2015, and the number of countries planting such crops increased to 28 countries by 2015 (James, 2016). The plantation of GM crops increased gains for farmers around the world by over US\$150 billion from 1996 to 2014 as a result of reduced chemical pesticide use, increased crop yields, and increased farmer profits (James, 2016).

Although the rapid evolution of the agricultural biotechnology industry resulted in a significant transformation in the aspects of agriculture, foodstuffs, and agrochemicals, considerable public concern about the “uncertainties” and perceived “risks” – both health-related and environmental – still surrounds GM technology (Costa-Font and Gil, 2009; Aerni and Rieder, 2001). In China, up to 80 percent of the general public harbors concern regarding GM foods due to safety-related problems in 2010 (Wang, 2015). The public’s negative response to GM foods may be associated with insufficient knowledge of GM technology, a lack of trust of developers and of relevant regulations, poor risk-benefit communication, and ethical values (Ishii and Araki, 2016; Lucht, 2015; Zilberman *et al.*, 2013). Growing public concerns about GM products have had considerable effects on national public policies and international trade (Aerni and Rieder, 2001). For example, in 2014, the Chinese Government leveraged public resistance to GM foods to delay the approval of the importation of several varieties of GM soybeans from the USA for consumption in China (USDA, 2014).

Government policymakers not only rely on public opinions but also consider the potential economic impacts and attitudes of economic interest groups. These groups tend to influence government policy through political lobbying or the mobilization of public opinion (Aerni and Rieder, 2001). Agribusiness firms in some industries related to GM technology play an important role in the development of GM technology policymaking and regulation (Robinson *et al.*, 2013; Phillips, 2002). Their attitudes toward risks and benefits of GM technology influence GM policies and shape international ethical and legal disputes on the application of GM technology in agriculture (Aerni and Rieder, 2001). For example, European countries have opposed GM crops in part because agricultural chemical firms have quietly lobbied the governments to prevent GM crops from limiting their pesticide markets in Europe (Graff and Zilberman, 2004). In contrast, American Government regulators have aligned their interests with companies such as Monsanto and the biotechnology industry to push for GM technology (Newell and Glover, 2003; Graff *et al.*, 2009).

In China, consumers have been consuming GM vegetable oil and farmers have been feeding their livestock imported GM soybean and maize feed since the early 2000s, but the government does not allow the cultivation of major GM food crops such as maize, rice, and wheat. This is partly attributed to a lack of consumer and agribusiness support for their production. As noted above, China used a lack of public acceptance as one of the most important reasons to delay import approval for GM varieties in 2014. In 2015, the Ministry of Agriculture (MOA) released a draft amendment to the Administrative Measures for the Safety Assessment of Agricultural Genetically Modified Organisms indicating that the approval process for GM products must consider economic and social factors (MOA, 2015).

Chinese consumers’ perceptions and attitudes toward GM foods have been addressed in a variety of studies (Huang and Peng, 2015; Huang *et al.*, 2006; Zhang *et al.*, 2010). However, few studies have specifically examined agribusiness firm attitudes toward GM technology and the potential profit changes resulting from the adoption of GM crops. We also have no knowledge of how many agribusiness firms in China are engaged in biotechnology research or of whether they are actively working to prevent GM crop production or encourage GM crop production in China. Resolving these issues will have important policy implications for the future of GM crop use in China and for government strategies on GM crop

commercialization. In view of this need, we surveyed 160 agribusiness firm managers in four industries (food, feed, chemical, and seed) and examined the agribusiness firm managers' attitudes toward GM technology and the main factors that influence their attitudes; how many agribusiness firms are engaged in biotechnology research and determinants of their decisions; and whether such firms have lobbied the government or attempted to convince Chinese biotechnology policymakers to encourage or prevent GM crop development and the major factors influencing such lobbying activities. Agribusiness firm covers broader than food, feed, chemical, and seed firms. It also include the ones in agriculture-related retailers, wholesalers, carriers, etc. But in this paper, our focus is the agribusiness firms along the rice and maize supply chains, which are closely related to agricultural biotechnology industry. The agribusiness firms in this paper are the ones in the food, feed, chemical, and seed industries.

In the following section, we present the data used. Section 3 presents descriptive results on managers' attitudes, biotechnology R&D investments, and lobbying activities. Section 4 explains conceptual frameworks used and presents the empirical results. The final section concludes with policy implications based on the findings.

## 2. Data

### 2.1 Questionnaire design and data collection

Rice and maize are two of the most important grain crops grown in China. GM traits of maize and rice had been approved as safe for human health, agriculture and the environment by Chinese biosafety authorities. GM maize and rice varieties, however, cannot be legally cultivated in China. Many varieties of imported GM maize and related products have long been consumed by consumers or used to feed animals in China. We focused on these two crops and surveyed industry representatives in the rice and maize supply chains, including seed, pesticide, feed, and food company representatives. Huang and Peng (2015) studied the consumers' attitudes toward GM foods, while Hu *et al.* (2011) worked on agribusiness firm investment in R&D. Thus questions regarding managers' attitudes toward GM foods and firm biotech R&D investment in our questionnaires were developed based on the previous questions about consumers' attitudes and agribusiness firm investments. Survey sections on expected profits and lobbying activities were added. The questionnaire contained two sections. The first section was developed to collect information on firm characteristics, product structures, R&D investments, and other company-level information. The second section included information on managers' attitudes toward biotechnology, profit expectations of GM crops, and lobbying activities at the manager level.

Surveys were conducted from 2013 to 2014 with a convenience sample of 160 managers in the four specified industries through face-to-face interviews, mail and e-mail correspondence and follow-up telephone calls. Due to difficulties associated with gaining access to high-level executives or managers in different industries, stakeholder representatives in the food, feed, chemical, and seed industries were identified with the help of key informants who were familiar with the topic and with relevant stakeholders. These key informants included representatives from the MOA, industry association, and local agricultural departments and an official who used to work on related topics at university.

A list of contacts at the top 70 seed firms was generously provided by the MOA. These firms form the backbone of China's seed industry, and their sales account for approximately 30 percent of China's seed market. An official working at the MOA seed department sent an introductory message about our survey to the 70 seed firms. Our professional research surveyors then called these managers. In total, 50 seed company managers responded via e-mail in 2014, forming our seed industry respondent sample.

With the help of the Pesticide Industry Association, face-to-face interviews with pesticide firms were conducted at a workshop on Environmentally Friendly Pesticide Processing

Technology and Production Equipment held in Shanghai in 2014. Most large chemical firms attended the workshop. The secretary of the Pesticide Association introduced our project and survey at the start of the meeting, and we selected a convenience sample of 53 chemical companies to complete the questionnaires. The 53 pesticide firms are major players in the chemical industry, seven of which are listed on Chinese stock markets. However, none of the firms is a multinational pesticide company.

An official working at the Agriculture Department of Zhejiang province sent messages on our project and questionnaires to feed company managers working in Zhejiang province. Then, 17 feed firms in Zhejiang province completed the questionnaires and sent them by express mail in 2013. These 17 feed firms are representative of mid-sized feed firms in Eastern China.

Confronted with the challenge of gathering a representative sample of food firms owing to a remarkably rich variety of food products and the enormous number of food companies in China, we finally decided to focus on food firms involved in grain processing or trading. With the help of an official who used to work at the Center for Chinese Agricultural Policy and the Chinese Academy of Science, we attended the Chinese Grain Market Outlook Conference held in Shandong province in 2013. We randomly identified grain or food companies to complete the questionnaire, and 40 firms responded. These firms are mainly engaged in grain (e.g. soybean, maize, and wheat) and oilseed business, and three are listed on the Chinese stock market.

### *2.2 Data analysis*

We collected data on managers' attitudes (1 = strongly supportive; 2 = partially supportive; 3 = neutral; 4 = partially opposed; 5 = strongly opposed) toward seven types of GM foods: GM tofu, GM soybean oil, GM pest-resistant transgenic rice, GM rice with improved nutrition, GM wheat, food containing GM maize ingredients, and pork fed with GM feed (such as GM maize). The results were analyzed by averaging all answers given. When the average value was greater (smaller) than three, managers' attitudes were set as negative (positive) toward GM foods. When an average value of three was found, managers were considered to view GM foods as neutral.

We surveyed how firm managers expected firm profits would change (1 = gain; 2 = loss; 3 = no change; 4 = not sure) if China were to commercialize insect-resistant (IR) rice. We applied this approach for two reasons. On the one hand, rice is one of the most important staple foods for the Chinese population. If it were commercialized for cultivation in China, this would have a considerable influence on relevant stakeholders such as farmers, consumers, and agribusiness firms. On the other hand, IR rice was assigned production safety certification in 2009, and this approval was extended to another five years in 2014. Therefore, GM rice is one of the crops that is most likely to be commercialized over the next several years in China.

In addition, managers' attitudes on the commercial cultivation of GM crops, their biotechnology R&D investments, and their political lobbying activities were analyzed. Due to trade secrets, few companies willingly provided data on how much they spend on biotechnology R&D. We instead asked them whether they are engaged in biotechnology R&D. When they stated that they were, we coded the firms as being investing in biotechnology research. Manager and firm characteristics were also surveyed.

### *2.3 Respondents' characteristics*

Most of the sampled firms are private firms. The average firm value measured by the registered capital is approximately RMB1.2 million (US\$180,000 equivalent). In terms of numbers of employees, the largest firms are the food firms ( $n = 1,748$ ), followed by the chemical ( $n = 1,113$ ), seed ( $n = 306$ ), and feed firms ( $n = 192$ ). The firm managers are in their

late 30s and early 40s, are predominantly male, and have worked for more than decade. The respondents are also highly educated – more than 80 percent have received a Bachelor's degree or above in seed, feed and chemical industries. However, most of the managers did not major in biology or related fields and possess limited knowledge on biotechnology. An exception is the managers employed in the seed industry. Approximately 68 percent of these managers majored in biology or in other related fields and have some biotechnology knowledge.

### 3. Descriptive analysis of agribusiness firm manager perceptions of GM technology

#### 3.1 Agribusiness manager attitudes toward GM technology

The managers' attitudes toward GM technology are presented in Table I. The table shows that the percentage of the agribusiness managers surveyed who view GM foods as acceptable is low. In total, 23 percent ( $n = 36$ ) of the 160 agribusiness managers believe that GM foods are safe for consumption compared to 13 percent of consumers who viewed GM food as being safe in 2012 (Huang and Peng, 2015). By contrast, approximately 61 percent of the managers hold negative views of GM foods, which is a higher value than that for consumers (45 percent) who have been reported to consider GM food unsafe (Huang and Peng, 2015). Such attitudes vary by industry. The managers who are most opposed to GM foods are employed in the chemical industry. The share of managers who hold positive views is 7.6 percent while the share of those who are opposed is more than 70 percent. Those exhibiting the most positive views are employed in the food industry (30 percent positive and 50 percent negative).

In total, 34 percent of the agribusiness managers support the commercial cultivation of GM crops in China (Table I). In terms of their attitudes toward the adoption of GM crops by industry, chemical industry representatives are the most opposed to GM crop adoption while food industry representatives are the most supportive. Less than 15 percent of the chemical managers support the adoption of GM crops while nearly half of the food managers surveyed do. Although most of managers acknowledge that GM technology would play a major role in improving food security, decreasing pesticide use, and improving China's environmental well-being, the surveyed respondents believe that the government should make more efforts to delay or stop the commercial cultivation of GM crops in China. They think scientific evidence on the safety of GM food is insufficient, the government thus should initiate more research on GM technology.

	Sample size	Attitude toward GM foods			Attitude toward the adoption of GM crops		Lobbying
		Positive	Neutral	Negative	Supportive	Opposed	
Total	160	22.5	16.2	61.3	33.7	66.3	13.1
Food	40	30.0	20.0	50.0	47.5	52.5	10.0
Feed	17	11.8	17.6	70.6	35.3	64.7	17.7
Chemical	53	7.6	20.7	71.7	13.2	86.8	3.8
Seed	50	36.0	8.0	56.0	44.0	56.0	24.0
Non-chemical firms with biotech R&D	28	50.0	7.1	42.9	71.4	28.6	46.4
Chemical firms with biotech R&D	17	11.8	17.6	70.6	11.8	88.2	5.9
Other firms without biotech R&D	115	17.4	18.2	64.4	27.8	72.2	6.1

**Table I.** Stakeholders' attitudes and political activities to influence government policy by industry and by biotech R&D

3.2 *Agribusiness firm biotechnology research and managers' profit expectations*

Although most of the agribusiness managers surveyed have negative views of biotechnology, nearly half of the managers stated that their firm profits would remain unchanged if China were to adopt GM rice (Table II). Only 16.3 percent of the managers stated believing that their firms' profits would increase if China commercialized the cultivation of GM rice while 20 percent of the managers reported that they would suffer losses. The expected change in profit resulting from the potential adoption of GM rice varies by industry. More food and seed firm representatives stated that they would benefit from the adoption of IR rice. No feed firms report that they would suffer losses. Among those firm representatives anticipating suffering losses, 63 percent are employed at chemical firms. A great number of chemical firm representatives also claimed that they are not sure of profit changes that would result.

Despite such negative attitudes and mixed feelings regarding expected profits from GM cultivation, 45 of the firms surveyed engage in biotechnology research (Table I). Among them, 28 are non-chemical firms (food = 3, feed = 3, and seed = 22), and 17 are chemical firms. Among those non-chemical firms that invest in biotechnology R&D, 50 percent are positive of GM foods and 71 percent support the adoption of GM crops. Remarkably, of the 17 chemical firms that invest in biotechnology research, 71 percent oppose the consumption of GM foods and 88 percent are unwilling to support the adoption of GM crops.

3.3 *Agribusiness managers' lobbying activities*

In aiming to capture the effect of managers' satisfaction with biotechnology policy on their lobbying activities, we surveyed whether managers are happy with current biotechnology policies. The results show that the vast majority of agribusiness firm managers surveyed said they were not happy with government policies on GM crops (e.g. ineffective biotechnology safety regulations, weak intellectual property protection mechanisms, and insufficient biotechnology R&D investment levels). Only nine firm managers stated being satisfied with existing biotechnology policies. In total, 101 managers argued that all biotechnology policies in China must be improved, whereas 42 of the managers argued that only biosafety regulations must be improved. Four each considered only intellectual property policies or government biotechnology R&D as being in need of improvement. For example, one firm manager recommended that the government should strengthen the enforcement of regulations that prevent the unauthorized use of GM maize, rice, and wheat seeds.

Although most of the managers surveyed are unsatisfied with the biotechnology policies, only 13 percent ( $n = 21$ ) reported that they have tried to lobby the government to change such policies. Lobbying activities reported by these 21 firm representatives take three forms: reporting GM-related problems to relevant MOA departments ( $n = 17$ ), holding press conferences on agricultural biotechnology ( $n = 1$ ), and funding GM-related academic conferences ( $n = 7$ ). For example, one seed firm representative reported speaking directly to President Xi Jinping and Premier Li Keqiang when they visited the research institute. The 21 firms that had lobbied the government consisted of 12 seed, 4 food, 3 feed, and 2 chemical firms.

**Table II.** Stakeholders' perceptions: expected profits from the adoption of GM rice

	Sample size	Gain	Percentage of firms		
			Loss	Not change	Not sure
Total	160	16.3	20.0	48.1	15.6
Food	40	25.0	7.5	65.0	2.5
Feed	17	11.8	0	88.2	0
Chemical	53	9.4	37.7	26.4	26.5
Seed	50	18.0	18.0	44.0	20.0

## 4. Model and empirical results

### 4.1 Econometric model and variables

To examine the main factors affecting managers' attitudes toward GM foods, biotechnology R&D investments, and lobbying activities, we developed three models.

First, we modeled a firm manager's attitudes toward GM foods as the interplay between the manager's profit expectations and firm industry. Graff *et al.* (2009) propose that agricultural biotechnology interest groups that would profit from the adoption of GM crops tend to support GM-friendly policies and GM products. We expected that managers who anticipate gains from the adoption of GM crops would be more likely to view GM foods favorably. We therefore considered managers' profit expectations in the attitude model. In contrast, some industries such as the agrochemical industry may lose from the adoption of GM crops due to reduced sales, whereas other industries such as the feed industry could gain from the introduction of GM products as a result of lowered input costs (Graff *et al.*, 2009; USDA, 2015). Firm industry may thus influence their attitudes toward GM products or technology. We also incorporate manager characteristics as control variables. For our dependent variable, we employed managers' attitudes toward GM foods. When a firm manager held a positive view of GM foods, we assigned a dependent variable value of one and a value of zero otherwise.

Second, we developed a model of biotechnology research as the correlation between profit expectations, managers' attitudes toward GM technology (including attitudes toward GM foods and attitudes toward the adoption of GM crops), and firm industry. Decisions made to invest in biotechnology R&D by private firms will depend on research profitability expectations (Caswell *et al.*, 1994). When the expected profits of investing in biotechnology R&D are greater, firms will invest. Therefore, firm managers' profit expectations are included in the equation. It is also important to examine whether managers' attitudes toward GM technology affect their investment decisions. In some industries, biotechnology is likely to be more important for productions of new products than for others. Thus industry dummy variables are incorporated to capture this effect. Firm characteristics are included as control variables. For the dependent variable, biotechnology R&D investment, firms only told us whether they have invested in biotechnology R&D or not. We thus used a probit model to estimate determinants of firm biotechnology R&D investment. When a firm reported being engaged in biotechnology research, we assigned a value of one to the biotechnology R&D investment dependent variable and a value of zero otherwise.

Third, a model of a firm's decision about whether to lobby the government to change existing biotechnology policies is employed to examine major factors affecting such lobbying activities. As a result of the introduction of GM crops, chemical firms in Europe and India suffered profit losses. These firms were thus very averse to GM technology and tried to lobby the government to slow down the commercialization of GM crops (Graff and Zilberman, 2004; Apel, 2010). We therefore consider managers' profit expectations and their attitudes toward GM technology in a lobbying model. Taylor (1997) observed that firms investing more in R&D are more likely to engage in political activities to influence national policy. Biotechnology R&D investment thus is included to capture the effect. Furthermore, the level of managers' satisfaction with biotechnology policy variable is incorporated to capture its effect on managers' lobbying activities. A firm's industry and manager and firm characteristics are applied as control variables. The dependent variable of lobbying is coded as one when a manager has lobbied the government to change biotechnology policies and as zero otherwise.

More specifically, we develop the following econometric models:

$$ATT_i = f(PE_i, TY_i, X_{1i}) = \theta_0 + \theta_1 PE_i + \theta_2 TY_i + \theta_3 X_{1i} + v_i \quad (1)$$



$$BRI_i = g(AT_i, PE_i, TY_i, X_{2i}) + \delta_i = \pi_0 + \pi_1 AT_i + \pi_2 PE_i + \pi_3 TY_i + \pi_4 X_{2i} + \delta_i \quad (2)$$

$$LBY_i = y(AT_i, PE_i, BRI_i, TY_i, HP_i, X_{3i}) + \xi_i = \beta_0 + \beta_1 AT_i + \beta_2 PE_i + \beta_3 BRI_i + \beta_4 TY_i + \beta_5 HP_i + X_{3i} \quad (3)$$

where the dependent variable  $ATT_i$  is the  $i$ th manager's attitude toward GM foods;  $BRI_i$  the  $i$ th firm's decision to invest in biotechnology research and  $LBY_i$  the  $i$ th manager's political lobbying activities. Given the nature of the dependent variables, we estimate the three equations using three probit regression models.

The profit expectation denoted by  $PE_i$  is a measure of managers' expectation of profit change that may influence managers' attitudes toward GM foods, biotechnology R&D investment decisions and lobbying activities. Gain, loss, and unsure variables are included as dummy variables while "no change" is employed as a base.  $TY_i$  is a vector of dummy variables representing each firm's industry. The chemical industry is used as a base.  $AT_i$  is the variable vector measuring managers' attitudes toward GM technology, including managers' attitudes toward GM foods and toward the adoption of GM crops. In terms of managers' food-related attitudes, positive and negative attitudes toward GM foods are taken as dummy variables, and neutral attitudes are employed as a base. In terms of adoption attitudes, we use a "supportive" variable as a dummy variable and an "opposed" condition as a base. To determine the effect of manager satisfaction with biotechnology policies on managers' lobbying activities, we also include a dummy variable,  $HP_i$ , in the lobbying activity model. This variable is coded as one when a manager is satisfied with current biotechnology policies and as zero otherwise. The other variables capturing manager and firm characteristics are incorporated as control variables.

#### 4.2 Empirical results

We use probit models to estimate the three models. The estimation results are reported in Table III.

*Attitude model.* After controlling for managers' characteristics, the results suggest that managers' profit expectations and firm industries significantly influence managers' attitudes toward GM foods. Different from what we expected, those who are not sure whether profits will change from the adoption of GM rice view GM foods more negatively than managers with unchanged profit expectations. We assume that this might be because firms that are uncertain of profit change tend to exaggerate the risk of profit losses. Although some scholars conclude that uncertainty may create opportunities for firms, lots of scholars also argue that these changes may exert a negative impact on firm (Chapman and Ward, 2002; Lorenzi *et al.*, 1981; Perminova *et al.*, 2008). In the field of GM technology in China, continuing controversy about the safety of GM foods have negatively affected the public perceptions of GM technology (Huang and Peng, 2015). During the interview, some managers also expressed more worries about consumers' concern although their firms would not suffer losses from the adoption of GM crops. Therefore, we think agribusiness firms that are not sure of potential profit changes from the adoption of GM rice are more likely to view GM food more negatively. Managers of food and seed firms view GM foods more positively than do their chemical firm counterparts. This is because food firms benefit from the adoption of GM crops as a result of lower input costs and seed firms can increase their market share by researching GM technology. During the interview, some managers expressed that production input made from GM ingredients are generally lower than others, thus they would love to use GM foods as raw material if national policies allow this.

*Biotechnology R&D model.* The results show that managers' attitudes toward the adoption of GM crops have a positive and significant effects on firm biotechnology R&D

**Table III.**  
Estimation results of  
managers' attitudes  
toward GM foods,  
firm biotech R&D  
investment, and  
managers' lobbying  
activities

	Managers' attitudes toward GM foods (ATT)	Firm biotech R&D investment (BRI)	Managers' lobbying activities (LBY)
<i>AT</i>			
Adoption attitude			
Supportive	\	0.885 (0.342)***	-0.119 (0.461)
Food attitude			
Positive	\	0.369 (0.441)	1.371 (0.695)**
Negative	\	0.286 (0.393)	0.359 (0.589)
<i>PE</i>			
Expectation of profit			
Gain	0.435 (0.352)	0.037 (0.385)	-0.492 (0.518)
Loss	-0.178 (0.372)	0.583 (0.340)*	-0.259 (0.521)
Not sure	-0.773 (0.464)*	-0.100 (0.387)	0.301 (0.549)
<i>BRI</i>			
Biotech R&D investment	\	\	1.146 (0.412)***
<i>TY</i>			
Industry			
Food	0.971 (0.416)**	-1.294 (0.433)***	0.927 (0.686)
Feed	0.388 (0.597)	0.135 (0.316)	0.983 (0.789)
Seed	0.773 (0.417)*	-0.428 (0.479)	1.172* (0.665)
<i>HP</i>			
Satisfied with biotech policy	\	\	-0.491 (0.749)
<i>X</i>			
Firm characteristics			
Ownership: state-owned	\	-0.211 (0.372)	0.025 (0.468)
Registration capital	\	1.152 (0.740)	0.931 (0.909)
No. of employee	\	0.308 (0.487)	-0.282 (1.037)
Manager characteristics			
Gender: male	-0.127 (0.384)	\	0.867 (0.702)
Age	0.064 (0.035)*	\	-0.007 (0.047)
Work time	-0.049 (0.031)	\	0.019 (0.041)
Education: ≥ bachelor	0.397 (0.365)	\	0.255 (0.465)
Biotech knowledge	0.010 (0.006)*	\	-0.012 (0.008)
Major: related to biology	0.079 (0.354)	\	-0.308 (0.464)
<i>Constant</i>	-3.950 (1.184)***	-1.199 (0.395)***	-2.201 (1.541)**

**Note:** \*, \*\*, \*\*\*Significant at 10, 5, and 1 percent levels, respectively

investments, but managers' attitudes toward GM foods do not significantly affect their investment decisions. This may be attributed to the fact that managers' attitudes toward GM foods reflect their personal opinions about whether to consume or purchase GM products as consumers, which would not exert an influence on firms' decision. Managers' attitudes regarding the adoption of GM crops appear to reflect their idea about GM technology as firm manager (producer) and would thus influence firm biotechnology R&D investment decisions. Although some firms that are engaged in non-food-related business might be against GM foods and support the crops such as Bt cotton, they might also be willing to invest in biotechnology research. We have tested that firms' product structure (whether they are engaged in food-related business) does not significantly influence their biotech investment decisions.

Managers' profit expectations from the adoption of GM rice also significantly influence firm investments in biotechnology R&D. Firms that expect losses are more likely to invest in

biotechnology research than firms that expect no change in profits. This suggests that firms may invest in biotechnology R&D for defensive purposes. Managers of such firms are concerned about not being competitive with foreign firms such as DuPont, Monsanto, and Syngenta and fear that they may lose markets to these firms if they are permitted to operate in China. Food firms are less likely to invest in biotechnology R&D than chemical firms. This is because food firms are less concerned about losing markets to foreign firms than chemical firms, which can incur significant losses when more IR GM crops become available on the market and can enjoy profits if pesticide-resistant crops are not marketed.

*Political lobbying model.* Managers' views on GM food consumption have significant effects on managers' lobbying activities. More specifically, the managers who are positive of GM foods are more likely to attempt to influence the government to change biotechnology policy. It suggests that managers' personal opinions of GM products are more likely to exert an influence on their lobbying activities. GM profit expectations held by managers do not significantly influence lobbying activities. This result diverges from our expectations based on studies conducted on Europe and India (Graff and Zilberman, 2004; Apel, 2010), where chemical firms expected to suffer losses from the introduction of GM crops and thus lobbied their respective governments to prevent GM crop adoption.

Firms that make biotechnology investments are more likely to lobby their governments to change biotechnology policies. These firms strive to secure a market for products resulting from their biotechnology research and thus push their governments to improve biotechnology policies. Furthermore, seed firms tend to be most active in lobbying activities. Manager dissatisfaction with current biotechnology policies does not drive managers to lobby the government.

## 5. Conclusions

Over the last two decades since the approval of GM cotton commercialization in 1996, the Chinese Government has spent billions of dollars on GM crop research to develop its own biotechnology industry (Gilmour *et al.*, 2015). Despite the repeated attempts made to reassure the public that GM foods are as safe as conventional foods, the government still faces strong opposition from consumers and from some of the agribusiness firms (Huang and Peng, 2015; Pray and Huang, 2008). Some agribusiness executives have even collaborated with parliamentary delegates to lobby the government to enact a separate law regulating the safety of GM foods (Patton, 2016). This paper attempts to examine how many Chinese agribusiness firms are concerned about GM technology (including GM foods and adoption of GM crops) and whether such firms invest in biotechnology R&D and lobby the government to promote GM-friendly policies. We also examine the major factors that influence managers' attitudes, R&D investments, and lobbying activities, which will have key policy implications for the government as it strives to achieve broader acceptance.

The results of this study show that most agribusiness managers in China are reluctant to accept GM foods and oppose the adoption of GM crops. However, a large share (nearly one-third) of firms invest in biotechnology R&D and nearly half of the managers surveyed claim that their firms' profits would remain unchanged if China commercialized GM crop. The vast majority of managers also expressed their dissatisfaction with policies on GM technology, but only 13 percent of the surveyed managers ( $n = 21$ ) reported that they have tried to convince the Chinese Government to change biotechnology policies ("lobbying").

In employing econometric models to reveal the main factors affecting managers' attitudes and biotechnology R&D investment and lobbying activities, we find that managers' profit expectations are the main factor shaping managers' attitudes toward GM foods and firm biotechnology R&D investment decisions. Whereas surveyed managers who reported being uncertain of profit changes presented more negative views of GM foods, managers expecting

profit losses reported being more likely to invest in biotechnology R&D. Firm biotechnology R&D decisions are also significantly influenced by managers' views on GM crop adoption. The results of the lobbying model show that positive views of GM foods and biotechnology R&D investment are positively associated with firm lobbying activities. However, managers' profit expectations from GM crops do not have a significant effect on their lobbying activities.

Given that China's biotechnology plan is to commercialize GM crops in the near future, the results of this study will have important policy implications for the development of agricultural biotechnology. Agribusiness firm reluctance to embrace GM technology is likely to become a major hurdle (similar to consumer concerns about GM foods) to China's plan to push for agricultural biotechnology. If the Chinese Government plans to promote the development of GM technology with broader acceptance while urging agribusiness firms to research biotechnology, it must make more efforts to quell public fears regarding GM product safety and related industry anxieties concerning the profitability of selling GM products. Strengthening the enforcement of intellectual property, and presenting a clear means to commercialize major biotechnology crop varieties will prove critical in addressing such fears.

On a positive note, leaders in China have recognized challenges associated with commercializing GM crops and have attempted to resolve such issues. First, the government has enacted relevant policies. For example, on its official website, the MOA initiated an online blog of "hot topics" and "GMO concerns" disclosing relevant laws, regulations and safety assessment standards to improve information disclosure on GM technology safety evaluations for the public (MOA, 2015). Second, according to its latest five-year plan on science and technology to 2020, the Chinese Government will advocate for the commercialization of soybeans – used in food products such as tofu, soy sauce, and animal feed – and corn and will reinforce R&D on these crops (State Council, 2016). This is the government's first attempt to outline specific GM crops to be commercialized, reflecting the government's decision to push for the use of GM technology in agriculture to improve the agricultural industry.

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