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Attitude Gaps with Respect to GM Non-Food Crops and GM Food Crops and Confidence in the Government's Management of Biotechnology: Evidence from Beijing Consumers, Chinese Farmers, Journalists, and Government Officials

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Received: 25 November 2019; Accepted: 24 December 2019; Published: 31 December 2019

Abstract: Most soybean oil consumed in China is made from imported genetically modified (GM) soybeans, while livestock are fed imported GM soy meal and GM corn. However, no GM food crops are allowed to be planted in China at present. That puts China in a confusing situation where GM foods can be eaten but cannot be grown. Many studies suggest that it is partially due to Chinese consumers' and government officials' opposition to GM technology. This is the first study that examines different stakeholders' and journalists' attitudes toward the commercialization of GM non-food crops and GM food crops and investigates the attitude gaps with respect to these crops. From 2015 to 2016, surveys were conducted face-to-face and by email with 1730 respondents, including 1460 consumers, 54 farmers, 70 journalists, and 146 agricultural officials. We find that nearly 60% of respondents are supportive of the commercialization of GM non-food crops, but less than 30% of respondents support the commercialization of GM food crops. Around 50% of respondents have no confidence in the government's management of biotechnology, while only 17% have confidence in the government's management. Those with lack of confidence in the government's management are less likely to support the commercialization of GM crops.

Keywords: attitudes; confidence in the government's management; GM crops; stakeholders

1. Introduction

Genetic modification technology has advanced by leaps and bounds over the last few decades [1]. In 2018 there were 26 countries that grew 191.7 million hectares of genetically modified (GM) crops. The four major GM crops adopted by these countries are soybean, maize, cotton, and canola [1]. The average biotech crop adoption rate in the United States is 93.3% (the average for soybean, maize, and canola adoption), while the rate for Brazil is 93%, for Argentina around 100%, for Canada 92.5%, and for India 95%. China, as one of the first countries to carry out the commercialization of GM crops, has only planted GM cotton and GM papaya widely [2]. Since 2006, no new GM crop has been approved for cultivation [3]. The ranking of China's planted GM crop acreage fell from fourth in 2002 to eighth in 2016, overtaken by developing countries such as India and Brazil [4,5].

China now follows the roadmap of "non-edible crops, indirectly edible crops, and directly edible crops" for the development of GM technology. The first step is to develop non-edible crops such as GM cotton. The second step, which involves the development of indirectly edible crops, includes feed and feed processing crops such as GM corn and GM soybean. The last step involves directly

edible crops such as GM rice. Despite the roadmap, China has been importing GM edible products since the 2000s. Most soybean oil consumed in China is made from imported GM soybeans, while livestock are fed imported GM soy meal and GM maize [6]. The net import of GM soybeans in China reached 95.42 million tons in 2017, which accounts for approximately 80% of soybean consumption [7]. That also puts China in a confusing situation where GM foods can be eaten but cannot be grown. Why is the Chinese government cautious of commercializing GM crops and why did they propose the "three-step" roadmap? Some scholars think that two of the most important reasons are Chinese consumers' concerns about GM technology and Chinese firms failing to develop GM crops that could compete with multinational corporations [6,8]. Others think that most Chinese government officials are not supportive of the cultivation of GM crops [9]. However, to date there are no studies that document Chinese government officials' attitudes toward the commercialization of different types of GM crops and the major reasons behind their attitudes.

Numerous studies indicate that confidence in the government's management of biotechnology plays a critical role in the attitudes toward GM foods and commercialization of GM crops [10–12]. When the public lacks sufficient knowledge of emerging technologies, they tend to rely on the government to make decisions for them to reduce the complexity of risk management [13]. A series of studies in China have shown that consumers' confidence in the government has a significant positive impact on their acceptance of GM foods [14,15]. Zhao, Deng, Yu and Hu [2] also indicate that confidence in the government's management of GM food labeling significantly influences Chinese public attitudes toward labeled GM products.

Therefore, the objectives of this paper are to examine different Chinese stakeholders' and journalists' attitudes toward the commercialization of GM non-food crop and GM food crops, confidence in the government's management of biotechnology, and the impact of the confidence on their attitudes. Although Zhao, Deng, Yu and Hu [2] have investigated different stakeholders' and journalists' awareness and attitudes toward labeled GM foods under the context of different labeling, they failed to examine the attitudes toward the adoption of GM crops and the attitude gaps between GM non-food crop and GM food crops. The stakeholders in this paper include consumers, farmers, and local agricultural officials from county agricultural departments. Research shows that people of different occupations have significant differences in attitudes toward GM products [16]. The reasons we focus on these groups are as follows. First, consumers are the final users of GM products, so their attitudes are important for both producers and policymakers. Deng, et al. [17] find that Chinese agribusiness managers were very cautious of the application of GM technology in production due to concern about Chinese consumers' negative perceptions. As indicated in numerous studies, consumers' concerns about GM technology are one of the most important reasons that the Chinese government is reluctant to develop GM technology [18]. Second, farmers are direct buyers of GM seeds. Their attitudes toward the adoption of GM crops could directly influence the demand of GM seeds. Third, government officials are the policy makers who decide whether GM crops will be commercialized. Government officials in our survey are the directors of agricultural departments in the counties of different provinces. Their attitudes, to some extent, represent the government officials' attitude toward the commercialization of GM crops and might represent the direction of GM technology development in China.

Journalists, as one of the most important biotechnology information distributors, also represent one of the research subjects in this paper. In theory, journalists should be impartial on any subject that they cover, including GM technology, and their personal attitudes must be put aside unless they are based on scientific evidence. However, in reality the media often portrays science as dangerous and mysterious and journalists tend to present pessimistic attitudes toward new technology [19]. Moreover, journalists' attitudes toward the cultivation of GM crops often influence the tone of their coverage, which might further influence the public opinion of GM technology. Therefore, it is necessary and important to explore these stakeholders' and journalists' attitudes toward the commercialization of different GM crops.

This study makes three central contributions to the current literature on GM technology. First, although a great body of existing literature has made great breakthroughs on different stakeholders' attitudes toward GM products, most studies mainly focus on consumers' attitudes. Second, there is little literature that documents different stakeholders' attitudes toward the commercialization of GM non-food crops and GM food crops and shows the attitude gaps between these crops. Third, this study considers the potential endogeneity of the confidence in the government's management of biotechnology and its impact on stakeholders' and journalists' attitudes.

2. Literature Review

There is a large body of literature on the different stakeholders' attitudes toward GM products, but most of the research focused on consumers [20]. Studies in the early 2000s show that consumers in the United States and some developing countries, such as Brazil and Iran, had a higher level of acceptance, while consumers in Europe and Japan had a relatively lower level of acceptance of GM foods [21–23]. A recent Eurobarometer report shows that 60% of European consumers have heard that there are GM ingredients in foods and drinks, and the share of European consumers who are concerned about GM ingredients decrease from 66% in 2010 to 27% in 2019 [24]. Nearly two-thirds of European consumers express that they would purchase GM potatoes at a price discount of 20% [25]. Lusk, et al. [26] report that around 45% of American consumers think that GM food is a safety concern and over 80% of American consumers are supportive of implementing the mandatory labeling policy on GM products [27]. The mandatory labeling of GM foods results in 19% less opposition to GM foods in the United States [28]. Almost all African consumers are willing to buy GM maize products, although the awareness of GM crops is low [29]. Over 60% of Brazilian consumers are willing to pay more for vitamin A-enriched GM cassava than traditional cassava [30], and more than half of highly educated Iranian consumers are willing to buy GM products [31]. In Korea, only 5.8% of consumers have positive attitudes toward GM foods [32].

A number of surveys have been conducted in China on different stakeholders' attitudes and perception of GM technology [16,17,33–63] (Table 1). The results show that the average share of consumers whose attitudes or perceptions were supportive or positive of GM foods before 2010 is around 45% while the share of consumers whose attitudes or perceptions were opposed or negative is around 16%. However, after 2010, the average share of consumers whose attitudes or perceptions were supportive or positive of GM foods is 23% while the share of consumers whose attitudes or perceptions were opposed or negative is around 41%. Some scholars point out that this is due to the widespread misinformation and rumors in China since 2010 [18,63]. The studies on firm managers and scientists after 2010 indicate that Chinese agribusiness managers and scientists also tend to be negative with respect to GM foods and oppose commercialization of GM crops.

Farmers, as GM seeds' users, are the principle beneficiaries of agricultural biotechnology. Their attitude toward the commercialization of GM crops will determine the demand for GM seeds, which in turn will influence the sales of GM seeds. A survey of European farmers in 2007 shows that around 35% of farmers in Spain, France, and Hungary are willing to adopt GM maize, while over 45% of farmers in United Kingdom and Germany are willing to do so [64]. However, a recent survey in Europe shows that over 70% of farmers in Poland are against the production and distribution of GM foods [65]. Al, et al. [66] show that most farmers in Bangladesh are willing to adopt Bacillus thuringiensis (Bt) Brinjal when they realize the benefits. Patil and Padaria [67] indicate that 61.67% of farmers in India are willing to adopt Bt brinjal. Although the government has not approved the commercialization of Bt Brinjal, Indian farmers are illegally growing it [68]. Research in China shows that all of farmers from northern provinces are planting GM cotton since it could save on labor, reduce pesticide use, and achieve higher yields and higher profits [69]. However, only 35.5% of farmers are willing to adopt GM rice in China [41].

Table 1. Different stakeholders' attitudes toward genetic modification technology in China from 2000 to 2016. GM: genetically modified.

Survey Time	First Author	Observation	Sampling Location	Respondents	Types	Attitude Classification		
						Positive/Supportive	Negative/Opposed	Neutral
2001	Kynda R. Curtis	598	Beijing	consumers	GM food	77.5		
2002	Jikun Huang	1005	11 cities	consumers	GM food	57.0	11.0	32.0
2002	Jikun Huang	1005	19 cities	consumers	GM food	37.0	13.0	50.0
2003	Peter Ho	1000	Beijing, Shijiazhuang	consumers	GM food	40.0	9.0	51.0
2003	Jikun Huang	666	11 cities	consumers	GM food	64.0	6.0	30.0
2003	Jikun Huang	334	19 cities	consumers	GM food	36.5	14.5	49
2003	Lan Lü	2006	Zhejiang Province	consumers	GM food	59.0	3.0	38.0
2006	Zhiqiang Liu	305	Jinan	consumers	GM food	20.2	13.5	66.2
2006	Lan Lü	2152	Zhejiang Province	consumers	GM food	72.0	14.0	14.0
2009	Lan Lü	1212	Zhejiang Province	consumers	GM food	57.0	29.0	14.0
2009	Meihua Zhou	300	Changsha	consumers	GM food	42.0	24.3	33.7
2010	Fei Han	1759	nationwide China	consumers	GM product	42.66	24.8	32.54
2010	Jikun Huang	429	19 cities	consumers	GM food	29.0	18.0	53.0
2010	Liangxuan Feng	1170	6 cities	consumers	GM food	55.5	25.4	19.1
2010	Liyan Fan	925	Shijiazhuang	consumers	GM food	19.9	12.3	67.8
2010	Juan Shen	493	Nanjing	consumers	GM food	19.7	20.5	44.2
2010	Pingxiu Li	200	Guangzhou	consumers	GM food	34.4	13.6	52.0
2001–2010 On Average						44.9	15.7	40.41
2011	Weicheng Wu	1000	Chengdu	consumers	GM food	34.0	24.3	41.7
2011	Xipeng Xue	170	Hangzhou	consumers	GM food	34.7	29.9	35.4
2012	Jikun Huang	1002	19 cities	consumers	GM food	13.0	45.0	42.0
2012	Jinli Ruan	200	Shenzhen	consumers	GM food	32.0	37.2	30.8
2012	Kaiyun Zheng	291	Chengdu	consumers	GM food	23.0	29.2	47.8
2013	Zhihao Zheng	962	15 provinces	consumers	GM food (rice)	29.9	70.1	
2013	Zhihao Zheng	952	15 provinces	consumers	GM food	27.5	26.4	46.1
2013	Yijing Zhang	952	15 provinces	consumers	GM food	26.2	27.1	37.9
2014	Mingyang Zhang	1000	Jiangsu province	consumers	GM product	22.6	34.5	42.9
2014	Qianru Li	361	Anhui province	consumers	GM food	10.2	50.1	39.6
2014	Xinmi Zhang	200	Chengdu	consumers	GM food	37.0	51.0	12.0
2015	Haiyan Deng	1460	Beijing city	consumers	GM food	18.2	55.1	26.7
2015	Yue Zhang	3780	nationwide China	consumers	GM food	20.4	35.1	44.5
2015	Wenjing Zhang	508	Xian city	consumers	GM food	8.55	42.28	49.17
2015	Langguo	187	Zhuzhou	consumers	GM food	24.6	66.8	8.6
2016	Lingxian Meng	934	Shanxi province	consumers	GM food	19.3	30.5	50.2
2016	Kai Cui	2063	nationwide China	consumers	GM food	11.9	41.4	46.7

Table 1. *Cont.*

Survey Time	First Author	Observation	Sampling Location	Respondents	Types	Attitude Classification		
						Positive/Supportive	Negative/Opposed	Neutral
2011–2016 On Average						23.1	40.9	37.6
2011	Hans D. Steur	252	Shanxi Province	women	GM food	29.76	22.2	48.02
2007–2008	Fei Han	739	nationwide China	farmers	Bt-cotton	96.8	0.8	2.4
2013	Qian Lu	547	Hubei province	farmers	GM crop	51.92	15.13	32.95
2013	Ruomei Xu	723	Anhui Province	farmers	GM rice	35.5	9.7	54.8
2013–2014	Haiyan Deng	160	nationwide China	firm managers	GM food	22.5	61.3	16.2
2013–2014	Haiyan Deng	161	nationwide China	firm managers	GM crop	33.7	66.3	
2007–2008	Fei Han	254	nationwide China	scientists	GM food/crop	44.25	7.45	48.3
2013	Jikun Huang	806	nationwide China	scientists	GM food	29.0		

There are few studies on government officials' attitudes toward the commercialization of GM crops. One of the major factors that influence European government officials' attitudes toward GM crops is political risk [70]. Since most of the public are suspicious of GM technology, liberalizing GM technology has become a political risk for European policy actors [70]. This makes the government officials cautious of the commercialization of GM crops in their countries. For example, local officials in Germany have implemented a universal ban on planting GM crops to ensure their political success [71]. In China, over 55% of government officials said that they could accept GM foods with labelling, which is much higher than the proportion of consumers and farmers who would accept GM foods with labelling [2].

The media is the tool for the public to get access to GM technology information, so how journalists disseminate information about GM technology has a significant impact on public attitudes [72]. Studies show that public support for GM foods in Australia increases significantly when there is less media coverage, while support is at its lowest level when there is greater media coverage [70]. Korean researchers divide journalists into two groups based on their risk perceptions of GM foods—ordinary journalists and science journalists [72]. Science journalists have more trust in genetic technology than ordinary journalists.

3. Materials and Methods

3.1. Survey and Sample

The purpose of this paper is to examine: (1) different stakeholders, namely consumers', farmers', and government officials', and journalists' attitudes toward the commercialization of GM non-food crops and GM food crops; (2) confidence in the government's management of biotechnology; and (3) the impact of confidence on stakeholders' and journalists' attitudes toward the commercialization of GM crops. A series of surveys among these stakeholders and journalists was conducted.

In order to get information about consumers' attitudes, we conducted a series of surveys in the urban area of Beijing in 2015. Since the consumers' attitudes might be different in each region of Beijing, we conducted the surveys across the city. Specifically, there are differences between central and peripheral areas, as well as differences in different directions. We divided Beijing into four quadrants based on the cardinal directions, each with three zones, inside, middle and outside. This divides Beijing into 12 sections. In each section, we chose one supermarket and one wet market to make our sample representative. The wet market is a place where individual farmers or private dealers sell vegetables, meats and condiments like edible oil, akin to a farmer's market in the United States. In Beijing, a large number of consumers go to the wet market or supermarket to buy edible oil and other food products. Consumers in supermarkets and wet markets are representative because they often decide which foods to buy for their family. We randomly selected consumers entering or exiting each market to interview face-to-face. We surveyed their attitudes toward the commercialization of GM non-food crop and GM food crops with the options of "supportive", "opposed", and "neutral". The respondents were also asked the question "Are you satisfied with the national GM safety policy managed by the government" with the options of "yes", "no", and "don't know". Finally, 1460 valid questionnaires were completed. For more details on the consumers' data, see Deng and Hu [63]. Due to budget constraints, we did not conduct a survey of rural consumers' attitudes toward the commercialization of GM crops in Beijing.

In order to capture Chinese farmers' attitudes toward the adoption of GM crops, we conducted a series of surveys among the chairmen of agricultural cooperation communities (ACC). The surveyed chairmen are also farmers in their respective villages. Specifically, we interviewed chairmen of the ACC at a conference regarding farm technology in 2016, which was held by the Chinese Ministry of Agriculture (MOA). During the conference, we conducted the surveys in two of the ten meetings. We interviewed 54 chairmen of the ACC face-to-face. The 54 ACC chairman farmers were from 14 provinces, including Jilin, Anhui, Shandong, Shanxi, Guangxi, Jiangsu, Jiangxi, Hebei, Henan, Hubei, Hunan, Gansu, Shaanxi, and Qinghai. There were 15 chairman farmers from Hubei, 9 from Hebei, 8 from

Henan, and 1–3 from the other provinces. The total number of ACC member farmers from these ACCs was 8262 and the average number of member farmers in each ACC was 153. All questionnaires completed by the 54 chairman farmers were valid. The survey questions are the same as the ones we conducted among the consumers. The chairmen of the ACC often have a significant influence on the production decisions of their ACC member farmers. Therefore, the surveyed ACC chairman's attitudes could to some extent represent the member farmers' attitudes.

Regarding government officials, we conducted the survey at a conference about agricultural technology and policy training organized by the MOA for agricultural directors from 300 top counties in China. Finally, 146 government officials were interviewed face-to-face. We also surveyed journalists from April to September 2015 who had written about biotechnology in China. We emailed the 70 journalists and all responded. The survey questionnaire for government officials and journalists is the same as the consumer questionnaire.

3.2. Empirical Model

Following the frameworks of Ding, et al. [73] and Deng and Hu [63], we employed a random indirect utility model to examine different stakeholders' and journalists' attitudes toward the commercialization of GM crops and the determinants of their attitudes in this study. We assumed that $U_{n,j}$ is the utility of individual n's attitude j toward the commercialization of crops, where the attitude j is either supportive (accepting) or not supportive (either neutral or opposed). The random utility model is:

$$U_{n,j} = V_{n,j} + \varepsilon_{n,j} \tag{1}$$

where $V_{n,j}$ is a function of the attributes of an individual n, and $\varepsilon_{n,j}$ denotes a random component. Then the utility function is as follows:

$$U_{n,j} = \alpha C_n + \beta S_n + \delta x_n + \varepsilon_{n,j} \tag{2}$$

where $U_{n,j}$ is the utility of an individual n when they make the choice j, C_n is individual n's confidence in the government's management of biotechnology, S_n represents the category of different stakeholders and journalists, and x_n represents personal characteristics. When individual n choose j, it indicates that choice j can yield the highest utility for him. The probability that individual n' s attitude j toward the commercialization of GM crops is:

$$P(Att = j) = \mathrm{P}(U_{n,j} > U_{n,i},\ \forall j \neq i) \tag{3}$$

Assuming that the error terms are independently and identically standard normal distribution, we could obtain the probability of the stakeholders' and journalists' attitude j toward GM crops as:

$$P(ATT = j) = \frac{1}{\sqrt{2\pi}} e^{-\frac{(\alpha C_n + \beta S_n + \delta x_n)^2}{2}} \tag{4}$$

Specifically, stakeholders' and journalists' attitudes toward the commercialization of GM crops are denoted by:

$$A_n = \theta + \alpha C_n + \beta S_n + \delta x_n + \varepsilon_n \tag{5}$$

The variable of confidence in the government's management of biotechnology (C_n) may be endogenous. On the one hand, as indicated in Deng and Hu [63], since the formation of confidence in the government's management of biotechnology is a complex process, there might be some unobserved variables that not only influence an individual's attitudes toward the commercialization of GM crops, but also highly correlates with the individual's confidence in the government's management. On the other hand, there may be a simultaneous endogeneity issue, which indicates that an individual's attitude toward GM crop commercialization also influences its confidence in the government's management.

If we estimated the model (5) directly, the result would be biased and inconsistent [74]. In order to resolve the endogeneity of the variable confidence in the government, we introduce an instrumental variable (IV) in the simultaneous equations. It is as follows:

$$\begin{cases} A_n = \theta + \alpha C_n + \beta S_n + \delta x_n + \varepsilon_n \\ C_n = \vartheta + \lambda IV_n + \phi S_n + \varphi x_n + \mu_n \end{cases} \quad (6)$$

where the IV_n is the instrumental variable of the confidence in the government. IV_n denotes an individual's opinion on the government's handling of territorial disputes with Japan, specifically the Diaoyu Islands incident, in which the Japanese and Chinese governments were involved. In 2012, Japan claimed that they would purchase three of the disputed islands, located between Japan and China, which immediately prompted debates throughout China. In 2013, the Chinese Government set up the East China Sea Air Defense Identification Zone, which includes the Diaoyu Islands, and announced that it would require all aircraft entering the zone to file a flight plan and to submit radio frequency or transponder information. An individual's opinion on the government's management of the territorial disputes is possibly related to an individual's confidence in the government's management of other issues, such as the management of biotechnology. Their opinions on the government's management of the territorial disputes do not correlate with their attitudes toward the commercialization of GM crops. Thus, it will not correlate with the error term ε_n.

All the independent and dependent variables are summarized in Table 2. The dependent variable A_n equals 1 if individual n's attitude toward the commercialization of GM crops is supportive; otherwise it is equal to 0. C_n is the government confidence variable, with α as the corresponding parameter. If an individual n is not satisfied with the government's management of biotechnology, C_n is equal to 1. If individual n is satisfied with or has no idea on the government's management, it is equal to 0. IV_n is a dummy instrumental variable with λ as the corresponding parameter. If IV_n equals 1, it indicates that individual n thinks the government handled the Diaoyu Island incident appropriately. If IV_n equals 0, this indicates that individual n thinks the government handled the Diaoyu Island incident too aggressively, too passively, or they had no idea. S_n is the stakeholder or journalist category vector. It contains three binary variables: farmers, journalists, and government officials. The consumer group is used as the baseline. x_n is a vector of individual characteristics and δ is a vector of parameters corresponding to it. Individual characteristics includes gender, age and their education level. θ is the constant term and ε_n is the error term.

Table 2. List of the variables with definitions.

Variable	Description	Mean	SD
Attitude toward:			
Commercialization of GM cotton	1 = support; 0 = do not support	0.59	0.49
Commercialization of GM maize used as feed	1 = support; 0 = do not support	0.30	0.46
Commercialization of GM soybean	1 = support; 0 = do not support	0.28	0.45
Commercialization of GM rice	1 = support; 0 = do not support	0.28	0.45
Confidence in the government			
Respondents have no confidence in the government management of biotechnology	Are you satisfied with the national GM safety policy managed by the government? 1 = no; 0 = yes or have no idea	0.47	0.50
Instrumental variable			
Do you think the government handled the Diaoyu Island incident appropriately?	1 = yes; 0 = no or have no idea	0.46	0.50
Population category			
Consumers	1 = yes; 0 = no	0.84	0.36
Farmers	1 = yes; 0 =n o	0.03	0.17
journalists	1 = yes; 0 = no	0.04	0.20
Government officials	1 = yes; 0 = no	0.08	0.28
Knowledge			
Knowledge of GM technology	Proportion answering five questions correctly	2.36	1.48

Table 2. *Cont.*

Variable	Description	Mean	SD
Characteristics			
Age	Years of age	35.88	12.0
Gender	1 = female; 0 = male	0.46	0.50
Bachelor's	1 = bachelor's degree; 0 = others	0.50	0.50
Above bachelor's	1 = above bachelor's; 0 = others	0.29	0.41

Source: Author's survey in 2015.

4. Results

4.1. Attitudes toward the Commercialization of GM Non-Food Crops and GM Food Crops

Based on the "three-step" policy of commercialization of GM crops in China, this paper aims to examine different stakeholders' and journalists' attitudes toward the commercialization of GM crops—non-food crops (GM cotton), indirectly-edible food crops (GM corn and GM soybean), and directly-edible food crops (GM rice). In this paper, GM corn refers to corn used as livestock feed. Results in Table 3 show that in total nearly 50% of respondents are opposed to the commercialization of GM crops in China, 36% are supportive of commercialization, and the rest are neutral. Support for the commercialization of non-food GM crops is around 60% while support for the commercialization of indirectly-edible food crops and directly-edible food crops is less than 30%. Specifically, nearly 60% of the respondents said that they are supportive of the commercialization of GM cotton, among which over 85% of government officials and journalists reported that they are willing to support the commercialization of GM cotton. Nevertheless, the support levels for the commercialization of GM soybean, GM corn and GM rice are not high although they are similar. Less than 30% of respondents are supportive of the commercialization of GM soybean, GM corn, and GM rice while nearly 60% are against the commercialization of these crops.

Table 3. Respondents' attitudes toward the commercial cultivation of GM crops (%).

	Crop	Attitude	Attitudes toward Commercialization of GM Crops (%)				
			Consumers	Farmers	Journalists	Government Officials	Total
Non-food GM crop	Cotton	Supportive	55.00	62.96	85.71	89.04	59.36
		Opposed	24.66	20.37	2.86	4.79	21.97
		Neutral	20.34	16.67	11.43	6.16	18.67
Indirect-food GM crop	Soybean	Supportive	23.63	24.07	67.14	58.22	28.32
		Opposed	63.15	59.26	20.00	32.88	58.73
		Neutral	13.22	16.67	12.86	8.90	12.95
	Corn	Supportive	24.73	25.93	71.43	62.33	29.83
		Opposed	60.00	51.85	14.29	29.45	55.32
		Neutral	15.27	22.22	14.29	8.22	14.85
Direct-food GM crop	Rice	Supportive	23.90	25.93	57.14	52.74	27.75
		Opposed	63.36	59.26	30.00	37.67	59.71
		Neutral	12.74	14.91	12.86	9.59	12.54
Total		Supportive	31.82	34.72	70.36	65.58	36.32
		Opposed	52.79	47.69	16.79	26.20	48.93
		Neutral	15.39	17.62	12.86	8.22	14.75

Source: Author's survey in 2015.

The groups that are more supportive are journalists and government officials. In general, over 65% of the journalists and government officials said that they would support the commercial cultivation of GM crops in China. Specifically, over 85% of journalists and agricultural government officials, as mentioned above, are supportive of the commercialization of GM cotton. For the indirectly-edible food crops, around 70% of journalists are supportive of commercialization, while nearly 60% of

government officials are supportive. The support for the commercialization of GM rice is lower for journalists and government officials, but the share is still over 50%.

Consumers and farmers are opposed to the commercialization of directly- and indirectly-edible food GM crops, but are most accepting of non-food crops like GM cotton. Specifically, nearly 60% of consumers and farmers reported that they oppose the commercialization of GM soybean, GM corn, and GM rice, while 25% of them said they would support the commercialization of these crops. Differently, the share of consumers and farmers who support the commercialization of GM cotton is over 55%.

Moreover, Table 4 presents the differences in attitudes by the respondents' education, age and gender. It shows that the respondents who have a bachelor degree or above are slightly more supportive of the commercialization of GM cotton, but are more opposed of the commercialization of GM rice. However, there is no differences in the attitudes by age and gender.

4.2. Stakeholders' and Journalists' Confidence in the Government's Management of Biotechnology

The results in Table 5 show that nearly 50% of respondents are not satisfied with the GM safety policy managed by the government, only 16% are satisfied, and the rest have no idea. Moreover, confidence in the government's management of biotechnology varies significantly among different stakeholders and journalists. Government officials have the highest level of confidence in the government's management while consumers have the lowest level of confidence. Nearly 60% of government officials reported that they are confident with the government's management while only 11% of consumers are confident. Nearly half of consumers said that they are not confident with the government. For farmers and journalists, 24.1% and 32.9% of them, respectively, show lack of confidence in the government's management.

Table 6 shows the relationship between stakeholders' and journalists' confidence in the government's management and their attitudes toward the commercialization of GM crops. Unsurprisingly, there are significant differences in the attitudes toward the commercialization of GM crops among the groups who are confident with the government's management and the groups who are not confident. Of the respondents who are confident with the government's management, over 60% are supportive of the commercialization of GM soybean, GM corn, and GM rice. Of the respondents who are not confident with the government's management, over 70% are opposed of the commercialization of GM soybean, GM corn and GM rice. However, regardless of whether the respondents have confidence in the government's management or not, the respondents' support for the commercialization of GM cotton is all over 50%.

4.3. Stakeholders' and Journalists' Knowledge about Biotechnology

In order to explore the stakeholders' and journalists' knowledge of biotechnology, the respondents were asked five true-false statement regarding biotechnology. The specific statements and the proportion of those that answered the statements correctly are shown in Table 7. The first two statements are used to check the stakeholders' and journalists' basic biology competence. The results show that the percentage of respondents who correctly answered the true–false statement "Ordinary tomatoes do not contain genes, while GM tomatoes do" is 57%, while the percentage of respondents who correctly answered the statement "In the lifetime of humans and animals, genes often change" is 53%. Regarding other statements to check the stakeholders' and journalists' knowledge of biotechnology, the proportion that had correct responses is between 30% and 50%. There are also differences among the four groups. Farmers have the lowest level of knowledge. Their correct response rate is 37%. Journalists and government officials have the highest level of knowledge. Their correct response rates are 68% and 66%, respectively.

Table 4. Differences in the attitude toward the commercialization of GM crops by education, age, and gender.

	Cotton			Soybean			Corn used as Feed			Rice		
	Supportive	**Opposed**	**Neutral**	**Supportive**	**Opposed**	**Neutral**	**Supportive**	**Opposed**	**Neutral**	**Supportive**	**Opposed**	**Neutral**
Education												
Below bachelor's	51.70	25.15	23.15	26.95	55.29	17.76	27.15	54.49	18.36	27.54	56.09	16.37
Bachelor's	59.86	21.35	18.79	27.42	61.14	11.44	28.47	57.53	14.00	26.84	61.61	11.55
Above bachelor's	68.55	19.08	12.37	32.25	57.80	9.95	36.56	51.34	12.10	30.10	60.22	9.68
Age												
<=30 years	59.74	20.13	20.13	29.41	53.64	16.95	30.46	50.60	18.94	30.07	54.17	15.76
30–40 years	55.77	25.24	18.99	23.08	67.31	9.61	23.80	63.22	12.98	21.88	68.03	10.09
40–50 years	62.95	22.95	14.10	29.51	60.65	9.84	33.77	57.71	8.52	28.85	62.95	8.20
>=50 years	59.84	20.87	19.29	32.28	57.48	10.24	33.07	53.54	13.39	29.13	58.66	12.21
Gender												
Male	62.40	20.77	16.83	31.95	55.27	12.78	33.76	53.04	13.20	30.67	57.29	12.03
Female	55.75	23.29	20.86	24.02	62.83	13.15	25.16	58.03	16.81	24.27	62.58	13.15

Table 5. Respondents' confidence in the government management of biotechnology (%).

	Confidence in the Government's Management of Biotechnology		
	Confidence	**Neutrality**	**No Confidence**
Consumers	11.16	39.11	49.73
Farmers	24.07	40.74	35.19
Journalists	32.86	24.29	42.86
Officials	60.27	17.12	22.6
Total	16.59	36.71	46.71

Source: Author's survey in 2015.

Table 6. The relationship between confidence in the government's management of biotechnology and attitude toward the commercialization of GM crops (%).

Crop.	**Attitude**	**Confidence in the Government Management of Biotechnology**		
		Confidence	**Neutrality**	**No Confidence**
Cotton	Supportive	83.28	57.64	52.23
	Opposed	8.71	16.38	31.06
	Neutral	8.01	25.98	16.71
Soybean	Supportive	63.76	26.61	17.08
	Opposed	26.83	50.39	76.61
	Neutral	9.41	22.99	6.31
Corn used as feed	Supportive	65.16	26.14	20.17
	Opposed	23.69	48.50	71.91
	Neutral	11.15	25.35	7.92
Rice	Supportive	60.28	26.46	17.20
	Opposed	28.22	52.91	76.24
	Neutral	11.50	20.63	6.56
Total	Supportive	68.12	34.21	26.67
	Opposed	21.86	42.05	63.96
	Neutral	10.02	23.74	9.38

Source: Author's survey in 2015.

Table 7. Respondents' knowledge of biotechnology (%).

Quiz Statements	**Percentage of Persons Answered Correctly (%)**				
	Consumers	**Farmers**	**Journalists**	**Government Officials**	**Total**
Ordinary tomatoes do not contain genes, while GM tomatoes do (false)	53.22	40.74	87.14	87.67	57.11
In the lifetime of humans and animals, genes often change (false)	49.25	48.15	68.57	82.88	52.83
It is impossible to transfer animal genes to plants (false)	37.47	29.63	64.29	58.90	40.12
Hybrid rice is GM rice (false)	44.59	42.59	74.29	79.45	48.67
If the parents' blood type is A and B respectively, the blood type of their children may be type O (true)	38.70	22.22	47.14	22.60	37.17
Total	44.65	36.67	68.29	66.30	47.18

Source: Author's survey in 2015.

4.4. Estimation Results

Table 8 shows the estimation results of impact of different stakeholders' and journalists' confidence in the government's management of biotechnology on their attitudes toward the commercialization of GM non-food crops and GM food crops. In the model of stakeholders' and journalists' confidence in the government's management of biotechnology, the instrumental variable representing stakeholders' and journalists' confidence in the government's management of the territorial dispute significantly influences their confidence in the government's management of biotechnology. This indicates that the instrumental variable is valid. It should be noted that the "no confidence in the government" variable equals 1 if individuals do not have confidence in the government's management of biotechnology, otherwise it equals 0. Therefore, the coefficient of the "confidence in the government" variable should be interpreted with care. If the coefficient is negative, it indicates that respondents who have no confidence in the government's management of biotechnology are less likely to support the commercialization of GM crops. If the coefficient is positive, respondents who have confidence in the government's management of biotechnology or who do not have opinions are more likely to support the commercialization of GM crops.

Table 8. Impact of respondents' confidence in the government management of biotechnology on attitudes toward the commercialization of GM crops.

Variable	No Confidence in the Government	Attitude toward the Commercialization is Supportive			
		Cotton	Soybean	Corn Used as Feed	Rice
No confidence in the government		−1.322 ***	−1.380 ***	−1.112 *	−1.221 ***
		(0.207)	(0.464)	(0.639)	(0.297)
Instrumental variable (IV)	−0.150 **				
	(0.064)				
Government officials	−1.002 ***	0.453 **	0.481	0.622	0.462**
	(0.134)	(0.200)	(0.328)	(0.382)	(0.211)
Farmers	−0.356 *	0.071	−0.197	−0.115	−0.086
	(0.185)	(0.196)	(0.212)	(0.232)	(0.219)
Journalists	−0.358 **	0.470 **	0.939 ***	1.028 ***	0.744 ***
	(0.160)	(0.202)	(0.272)	(0.289)	(0.202)
Knowledge	0.059 ***	0.123 ***	0.057 **	0.084 ***	0.058 **
	(0.023)	(0.022)	(0.024)	(0.024)	(0.024)
Female	−0.047	−0.080	−0.181 ***	−0.187 ***	−0.142 **
	(0.064)	(0.062)	(0.070)	(0.070)	(0.069)
Age	0.012 ***	0.002	−0.004	−0.004	−0.007 *
	(0.003)	(0.003)	(0.005)	(0.005)	(0.004)
Bachelor's	0.258 ***	0.131 *	−0.110	−0.132	−0.147
	(0.076)	(0.077)	(0.113)	(0.124)	(0.093)
Above bachelor's	0.377 ***	0.360 ***	0.066	0.112	−0.022
	(0.096)	(0.093)	(0.128)	(0.139)	(0.114)
Constant	−0.669 ***	0.341 **	0.132	−0.053	0.164
	(0.136)	(0.135)	(0.188)	(0.231)	(0.161)
N	1730	1730	1730	1730	1730

Note: Standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

The estimation results show that stakeholders' and journalists' confidence in the government's management of biotechnology has a significant impact on their attitudes toward the commercialization of GM crops. Compared to the respondents who have confidence in the government's management of biotechnology, those who have no confidence in the government's management are less likely to support the commercialization of all the GM crops, including GM non-food crops and GM food crops.

Attitudes toward the commercialization of GM crops vary significantly among different stakeholders and journalists. The coefficients of the "government officials" variable are significantly positive in the models of attitude toward the commercialization of GM cotton, GM corn and GM rice. This indicates that government officials are more likely to support the commercialization of GM

cotton, GM corn and GM rice than consumers. The coefficients of "journalists" in the four models are significantly positive. This indicates that compared to consumers, journalists are more likely to be supportive of the commercialization of these GM crops. However, there is no significant difference in the attitudes between farmers and consumers.

The level of biotechnology knowledge has a significant impact on the stakeholders' and journalists' attitudes toward the commercialization of GM crops. In the four models, the coefficients of respondents' knowledge of biotechnology are all significantly positive. This indicates that the higher level of biotechnology knowledge the respondents have, the more likely they support the commercialization of GM crops.

The personal characteristics of the respondents also influence their attitudes. The coefficient of the "female" variable is significantly negative in the models of attitudes toward the commercialization of GM soybean, GM corn and GM rice. This indicates that female respondents are less likely to support the commercialization of these GM crops than male respondents. The coefficient of "above bachelor's" variable is significantly positive in the GM cotton model. This shows that those who have completed higher education are more likely to be supportive of the commercialization of GM crops.

5. Discussion and Conclusions

In this study, we examined different stakeholders' and journalists' attitudes toward the commercialization of GM non-food crops, indirectly-edible GM food crops and directly-edible GM food crops, and investigated the impact of confidence in the government's management of biotechnology on the stakeholders' and journalists' attitudes. Stakeholders include consumers, farmers and government officials. GM crops are non-food crops such as GM cotton, indirectly-edible food crops such as GM soybean and GM corn used as feed, and directly-edible food crops such as GM rice.

The results show that nearly half of stakeholders and journalists are opposed to the commercialization of GM crops, but there are big differences in the attitudes toward the commercialization of different GM crops. More than 50% of the respondents support the commercialization of GM cotton, while only 28% support the commercialization of GM food crops, such as GM soybean, GM corn, and GM rice. Because GM cotton is a non-food crop, the public will be more open-minded toward its commercialization. However, GM corn, GM soybean, and GM rice are food crops, so the public will be more sensitive to their commercialization. This is consistent with the study of Huang and Peng [18], that concludes around 50% of consumers consider consumption of GM food unsafe while only 13% consider it safe. In addition, it is in line with Chinese agribusiness managers' expectations that a large number of Chinese consumers tend to oppose the commercialization of GM crops [75].

There are also big differences in attitude toward the commercialization of GM food crops among different groups. Most consumers and farmers do not support the commercialization of GM food crops, while most journalists and government officials tend to support their commercialization. Studies show that Chinese consumers' opposition to GM technology is mainly due to their concerns about food safety [18,76]. The results about Chinese farmers' opposition to adoption of GM food crops are consistent with other studies in China, Pakistan, and Poland [41,65,77,78], although it is different from the studies in some Asian countries [67,79]. Ali and Rahut [78] suggest that most Pakistani farmers are unwilling to plant GM food crops or vegetables, although they are willing to adopt GM cash crops like GM cotton. Rzymski and Krolczyk [65] find that the group in Poland that is most skeptical of GM technology is farmers. However, farmers in Bangladesh are willing to plant Bt Brinjal when they realize its benefits [80], while over half of Indian farmers are willing to plant it [67,68]. The result of most Chinese farmers being opposed to GM food crops is consistent with findings from Pakistan and Poland [65,78].

There are three reasons that might explain why Chinese farmers are reluctant to plant GM food crops. Firstly, there are a number of debates and controversies about the adoption of GM food crops in China. For example, rumors like "GM corn caused the extinction of mice in Shanxi and Jilin" could negatively influence Chinese consumers' attitudes toward GM foods [63]. It might also significantly

influence Chinese farmers' attitudes toward the commercialization of GM food crops. Second, stringent legislation and policies regarding GM crops or products could have a significant influence on Chinese farmers' attitudes toward the commercialization of GM corps [41]. Pakseresht, et al. [81] indicate that Swedish consumer acceptance of GM foods has been significantly influenced by restrictive policies. Third, Chinese farmers have less knowledge about GM technology, which results in an increased opposition to GM food crop adoption. Differently, Chinese journalists and government officials are more knowledgeable about GM technology and related policy. They have a better understanding of the risks and feel more certainty about GM crops than consumers and farmers.

Nearly half of the stakeholders and journalists have no confidence in the government's management of biotechnology. Government officials have the highest level of confidence in the government's management of biotechnology. Consumers have the lowest level of confidence in the government. This might be because consumers do not know the great efforts that the government has made in the management of biotechnology. For example, China has developed a comprehensive biotechnology policy and regulatory system which governs agricultural biotechnology development. The government has created the National Biosafety Committee, which is mainly responsible for processing domestic and foreign applications for GM products' biosafety certificates [82].

Respondents who have no confidence in the government's management of biotechnology are less likely to support the commercialization of GM crops. This is consistent with the findings of Zhang, Chen, Hu, Chen and Zhan [62], who find that the level of consumers' acceptance of GM soybean oil is higher when consumers trust government agencies working on genetically modified organisms. Some scholars point out that this might be due to the fact that an individual's confidence in the government's public management capabilities can compensate for their concerns about GM foods due to their lack of knowledge [22].

Respondents lack of knowledge to understand biotechnology. The more knowledge the respondents have of biotechnology, the more likely they are to support the commercialization of GM crops. This is consistent with the study by Qiu, Huang and Yang [14] that indicates that those with more knowledge of GM technology are more scientific and rational when they weigh the pros and cons of the development of GM crops.

The higher level of education respondents has, the higher probability they will support the development of GM crops. This result is consistent with the study done by the International Committee on Information, which indicates that the higher level of education consumers have, the more receptive they are to GM foods [83]. The reason for this is that respondents with low levels of education are more susceptible to misinformation about GM crops. In China, there is much misinformation about GM technology, which also significantly influences Chinese consumers' attitudes toward GM technology [63].

The results of this study have the following policy implications. First, the government should make a greater effort to gain the public's confidence in their management of biotechnology, this could be done by increasing public awareness of the government's activities and their successes in improving GM food safety. Second, if the government plans on promoting the benefits of biotechnology with the hope that there will be more public supporters of the commercialization of GM crops, they should begin with popular science programs that focus on the basics of biotechnology.

The limitations of this study should be emphasized. Firstly, we surveyed as many respondents as possible and the total number is 1730 respondents, but over 80% of the respondents were consumers. Despite the fact that this enabled a comparison among groups who are involved in the development of GM technology, it might not represent the Chinese public's attitudes toward the commercialization of GM crops. Secondly, the final sample size of some groups (e.g., farmers (n = 54); journalists (n = 70)) was not large, while consumers in other provinces were not surveyed. If we could increase the sample size of farmers, media, and consumers in other provinces, it would provide results that are more robust and persuasive.

Author Contributions: Conceptualization, R.H. and H.D.; methodology, R.H. and H.D; software, C.Y.; validation, R.H., H.D., and C.Y.; formal analysis, C.Y. and H.D.; investigation, R.H. and H.D.; resources, R.H.; data curation, H.D.; writing—original draft preparation, C.Y.; writing—review and editing, C.Y. and H.D.; and funding acquisition, R.H. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the National Science and Technology Major Project of China (2018ZX08015001).

Acknowledgments: We would like to gratefully acknowledge the research team members who participated in the baseline survey.

Conflicts of Interest: The authors declare no conflict of interest.

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