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Is Implementing a Biotech Ban Correct or Not? Analysis of Farmer Perceptions and Attitudes on the Philippine Supreme Court's Ban on Biotech Crops

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Abstract: Several studies have explored the effects of restrictive policies in different case-use instances; however, studies focusing on restrictive agricultural policies and their effects on major stakeholders are scarce. While the Philippines has been increasing its support for biotech-related technologies in agriculture, such as the recent approval of Golden Rice and *Bt* (*Bacillus thuringiensis*) eggplant for cultivation, the years prior to 2020 have not been as lenient in the acceptance of biotech crops. This paper explored the perceptions and attitudes of biotech corn farmers on the Philippine Supreme Court's ban on biotech crops in 2015 and discussed how this restrictive agricultural policy could affect rural Filipino communities. A bifurcation was observed regarding the farmers' ban perception, with almost half indicating that implementing the ban was an incorrect decision. The effects of the decision-making stages and influential factors on farmers' perceived correctness of the ban were modeled using ordinal logistic regression and Spearman correlation. It was observed that while farmers' initial instinct is directly related to their ban perception, succeeding decision-making stages enforce the notion of a pragmatic point of view leading to innate resistance effects towards the ban. Furthermore, internal factors (such as income and satisfaction) and external family-related factors perturb their ban perception. This information can offer guidance on how future restrictive agricultural policies may be framed to avoid conflicting interests between policymakers and stakeholders. This also highlights the need to understand farmer perspectives and attitudes to gain critical information regarding technology adoption and development.

Keywords: biotech corn; farmer perceptions; restrictive agricultural policy; biotech ban; consumer decision model; biotech crops

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1. Introduction

According to the FAO 2020 report, 690 million people (8.9% of the world population) were undernourished prior to the COVID-19 pandemic, and the figures are continuously rising [1]. Sixty million more people have been affected by hunger since 2014 and if this trend continues, the number of undernourished people is estimated to exceed 840 million by 2030. These pressing issues of food insecurity and malnutrition are further aggravated by persisting problems pertaining to climate change, a booming population, urbanization, land degradation, migration, and the ongoing COVID-19 pandemic. Sustained efforts in addressing these problems involve the international and multisectoral collaboration of different fields, such as agriculture, food, and health. There is also a need to rebalance agricultural policies towards more nutrition-sensitive policy actions and focus on solutions that can mitigate the lingering problems affecting global food production, distribution, and sustainability. These are imperative to be on track with the world's SDG targets, particularly in ending hunger, food insecurity, and all forms of malnutrition for the decades to come.

Biotech crops are a prime example of agricultural modernization, which shows how the field of agriculture continues to adapt in the modern era, most especially in the 4th industrial revolution (4IR). Despite the persisting challenges faced by the field of agriculture, it was reported that from 1996 to 2018, the socio-economic benefits of biotech crops involved increasing food productivity, supporting nations' self-sufficiency in terms of arable lands, conserving biodiversity, mitigating climate change challenges, and contributing economic, health, and social improvements [2]. In the Asia and Pacific region, the leading country in terms of biotech crop propagation is India with 11.9 million ha of cotton, followed by China with 3.2 million ha of cotton and papaya, Pakistan with 2.5 million ha of cotton, and the Philippines with 875,000 ha of biotech corn [2].

In December 2002, the Philippines was the first among Southeast Asian countries to approve the application of biotechnology in agriculture, specifically biotech corn, for feed production. Biotech corn's commercial propagation was approved by the Department of Agriculture (DA) and Bureau of Plant Industry (BPI). It was fundamentally designed to be resistant to the Asiatic Corn Borer (ACB), *Ostrinia furnacalis* (Guenee), one of the most damaging corn pests in the Philippines. *Bt*, which stands for *Bacillus thuringiensis*, can enable corn borer resistance once certain genes from this bacterium have been isolated and inserted into the genes of corn plants. In the latest report of ISAAA (2019), the country ranked 12th worldwide in the list of biotech-mega countries, with 0.9 million ha allotted for biotech corn [2]. Through the years, farmers reported a sustained increase in yield and income as well as a reduction in insecticide use [3–5]. The specific accumulated income gains in the Philippines for biotech corn since its approval are US$553 million for insect-resistant (IR) corn and US$171 million for herbicide-tolerant (HT) corn [6]. Furthermore, the total factor productivity growth in the Philippines' corn industry was around 11.45% higher because of biotech corn adoption [7]. In July 2021, the Philippines was also the first country to approve the cultivation of Golden Rice, a biofortified rice variety with provitamin A, after the safe consumption approval of Australia, New Zealand, Canada, and the United States [8]. In the same month and year, the Philippines also approved the cultivation of *Bt* eggplant for food, feed, or processing (FFP) after it was declared safe for consumption by the DA-BPI. Ex-ante impact assessments regarding the adoption of *Bt* eggplant reported that its commercialization will increase marketable yield by 192% and reduce pesticide application by 48% per hectare [9].

Although the Philippines is currently increasing its support for biotech-related technologies in agriculture and the adoption of biotech cultivars, national policies pertaining to biotech crops have been strict from the early 2000s up to the latter years of the 2010s. As a case in point, the Supreme Court banned the nationwide field testing of *Bt* eggplant and the commercialization, propagation, and importation of genetically modified (GM) products in the Philippines on 8 December 2015. However, this ban was lifted on 26 July 2016, as a result of the appeals from the local and international scientific communities [10]. Nevertheless, this ban caused a decline in the harvested area for biotech corn up to 2017 [11], which had negative consequences for the livelihood of farmers growing this crop. In a span of 16 weeks, various media companies monitored the debates that developed around this issue, thereby placing agricultural biotechnology in the limelight, which is in contrast with the usual low media coverage given to science-related news [12]. Aside from the reversal of the Philippine Supreme Court's decision and high press attention given to this issue, it is also imperative to understand the perceptions of biotech farmers on this ban, since they are the prime stakeholders who would be heavily affected if the nationwide ban persists. With thousands of Filipino farmers relying on biotech corn for their main source of livelihood, the ban would equate to the loss of jobs and livelihood, which is a heavy blow to farmers' daily lives and communities. This aspect was not covered much by the press and mass media, but analyzing this angle is equally vital for the implementation of future government strategies and agricultural policies. This paper aims to contribute to this knowledge gap.

As argued earlier, the nationwide ban on biotech crops can be seen as a restrictive policy when applied to the case of biotech corn farmers. There are different theoretical lenses on how this can be viewed. First is the concept of deterrence and compliance. The implementation of nationwide restrictive policies requires compliance from its target population, and based on the traditional Deterrence Theory [13], it is generally assumed that the target population will follow the law because it is the right thing to do. The theory also assumes that people follow rules for fear of being punished and that people rationally calculate the potential cost of penalties and sanctions. Second is the concept of persuasion. People would comply with restrictive policies depending on the level of persuasion they have. The Elaboration Likelihood Model explains that people undergo two mental routes when it comes to persuasion and attitude change [14]. One is the central route, a cognitive processing path where a person scrutinizes a message and carefully thinks about issue-relevant arguments contained in persuasive communication. The other path is called the peripheral route or a mental shortcut process, where a person accepts or rejects a message based on irrelevant cues or if the persuader has high source credibility. In short, the difference between the two routes is how much cognitive effort a person is willing to give towards a certain issue that can lead to persuasion, and in this case, compliance with a policy. Third is the concept of costs and benefits. The theory of cost–benefit analysis assumes that decisions are evaluated in terms of their consequences [15]. Altogether, these theories, which focus on explaining the concepts of deterrence, compliance, persuasion, costs, and benefits, serve as foundations for understanding the perceptions and attitudes of biotech corn farmers on the ban on biotech crops.

Understanding Farmers' Perspectives on Restrictive Policies

Various papers on rural sociology and farmer decision-making have tried to understand farmers' perspectives towards different agricultural policies and model their cognitive behavior in adopting innovations [16–20]. Understanding farmers' perceptions and attitudes, as well as their causes and effects, can significantly aid in the creation and implementation of future policies. Gaining knowledge about the relationship between farmers and the technologies they are adopting, as well as the decision-making processes they are performing individually and collectively, would help in crafting better approaches towards the development of the agricultural sector.

While a lot of papers have focused on analyzing farmer decision-making regarding agricultural policies, there is still a limited amount of research on restrictive policies, which pertain to bans and prohibitions on certain technologies and farming methods. In a study that analyzed farmers' perceptions towards a decade-long grazing ban policy in Northern China, it was observed that farmers are more inclined to give more importance to short-term economic interest than ecological protection [21]. The study was conducted in ethnic minority areas where the grassland is a main source of income; hence, the farmers are experiencing difficulty in complying with the mandatory changes of the Grazing Ban Policy (GBP). As a result, more than 70% of the farmers engaged in illegal grazing after the GBP was implemented. Another study investigated farmers' attitudes towards stringent water-saving policies [22]. The policies involve restricting household agricultural water use, closing wells, reducing farmland, increasing water prices, and allocating surface water among upper, middle, and lower beaches, which all entail negative influences on the agricultural production of farmers. The study found that farmers' awareness of the positive consequences of the household agricultural water restriction and their perception of policy enforcement had significant relationships with their attitudes towards the stringent water-saving policies. The study recommended strengthening open and fair policy enforcement, cautiously utilizing water prices as a tool in controlling irrigation water and enabling the local farmers to be more informed about these policies. Meanwhile, another paper focused on qualitative approaches to knowing farmers' perceptions of the effectiveness of drought policy implementation [23]. It reported that farmers' past experiences are directly related to their policy implementation perceptions. Moreover, it was also observed that farmers' local

level adaptation is oriented towards income diversification and short-term market rewards. The study thus recommended strengthening local level long-term adaptation strategies such as awareness-raising, capacity building, watershed management, and source conservation to ensure the effectiveness of policy implementation. Meanwhile, a study conducted in Pakistan has shown that farmers are willing to abandon agricultural lands in search of better income-generating endeavors. The impacts of this agricultural land abandonment and land-use change are the increase in urban diffusion, weed infestation, farmland prices, and pressure on the present area infrastructure [24]. Another paper in the same country, which conducted a constraint analysis on livestock farmers, concluded that a comprehensive policy framework should be enacted that can address constraints on farmers' knowledge, awareness of diseases, and weak finances, among others [25]. These studies show the importance of understanding farmers' perceptions and attitudes towards restrictive policies since these may influence their future behavior and farm decisions. Furthermore, it can also determine the percentage of their possible compliance or non-compliance.

The goals of this paper are twofold, namely: to examine the perceptions and attitudes of farmers regarding the Philippine Supreme Court's ban on biotech crops, in connection with their decision-making stages and factors influencing their biotech corn adoption; and to highlight the potential impacts of restrictive agribiotech policies on rural communities. Since the Philippines is currently increasing its support for biotech crops because of their positive economic, environmental, and social impacts, it is vital to know how biotech corn farmers respond to changes in agricultural policies, most especially restrictive ones, as shown in this study. These data will be helpful in planning for future policies connected to biotech crop diffusion and adoption. Furthermore, this may contribute to the prevention of farmland abandonment since biotech corn can provide stability in the farmers' lives and communities. It is important to note that this study did not measure actual behavior but focused more on the decision-making process of farmers. Moreover, the farmers—who are normally treated as producers—were treated as consumers/adopters (i.e., biotech corn technology) in this study, which is why a model focusing on consumer decision-making was utilized to aid the data-gathering process.

2. Study Area and Methods

Since this paper aims to analyze the perceptions of biotech corn farmers towards the ban on biotech crops, the province of Pampanga, Philippines was selected as the study area (Figure 1). This is one of the provinces where biotech corn was first introduced in 2003 and it has been consistently producing biotech corn since then. The province of Pampanga is in the Central Luzon region and is classified as a first-class, highly urbanized city. Rice is grown in most lowland areas, while corn is the second major crop during dry seasons. Other top agricultural crops in the province are coconut, mango, and banana. The total farmland area of the province as of 2018 is 64,959 ha and the rural population is around 875,953 [26]. The Office of the Provincial Agriculturist (OPAG) stated that three of the top biotech corn-producing municipalities in the province are Arayat, Magalang, and Mexico, which is why they were chosen as the sampling sites for this study. The study employed a cross-sectional survey to interview 111 biotech corn farmers. Respondent-driven sampling—a specialized form of snowball sampling—was used to track down the target respondents of the study, with the help of government officials and farmer leaders. This employed a similar sampling approach used in previous studies that also tracked down and interviewed biotech corn farmers [27,28].

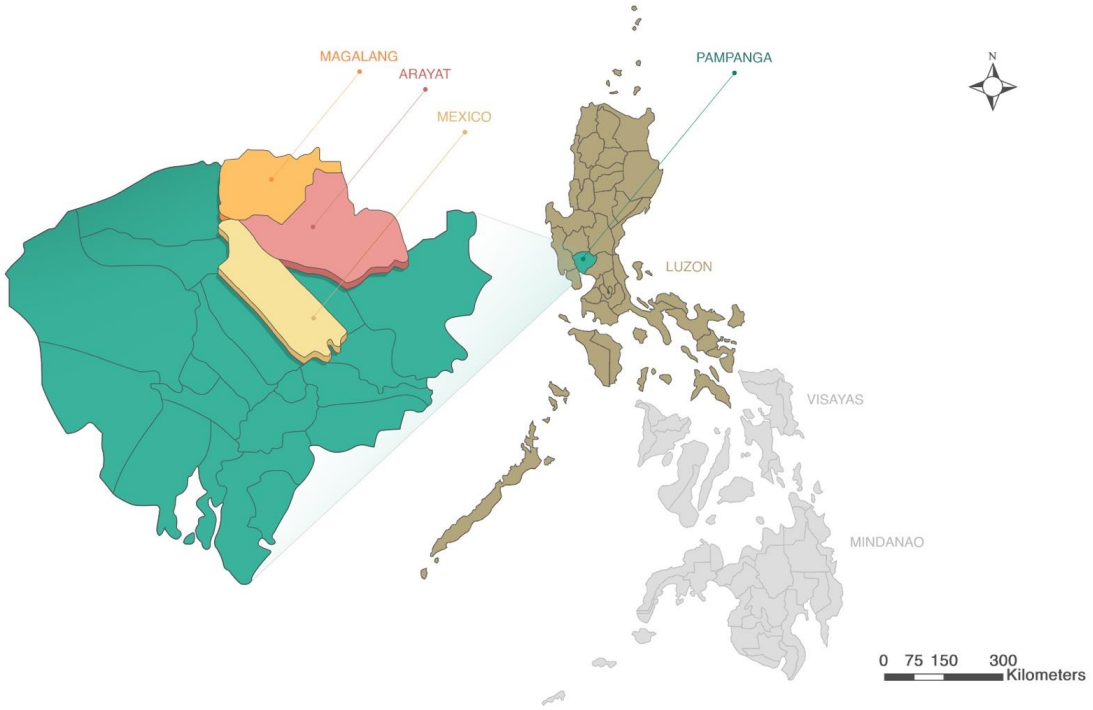

Figure 1. Sampling sites of the study showing the top producers of biotech corn in Pampanga province, Philippines.

All the farmers confirmed that they are planting the yellow corn hybrid with *Bt*-induced pest resistance, with the most common seed type being the Syngenta Agrisure NK8840 *Bt*/GT, which has big cobs and kernels, low ear placement, and high shelling recovery. They are also planting the yellow corn hybrid DEKALB 6919S Genuity 5% RIB with *Bt* technology, Roundup Ready (Monsanto, St. Louis, MO, USA) weed control technology, and high shelling recovery.

Data were collected using a standardized questionnaire from February to March 2018, which was administered through face-to-face interviews to obtain the answers and explanations of the farmers. All the respondents signed an informed consent form to confirm their participation in the study. The contents of the questionnaire included: (1) socio-demographic and farm-related information about the farmers; (2) information regarding their biotech corn adoption; (3) decision-making towards the biotech ban; (4) influential factors affecting their biotech farming practice; and (5) perceived correctness of the biotech ban.

Theoretical Framework

The study was guided by the Consumer Decision Model (CDM) [29]. In this study, the farmers are treated as consumers/adopters of the biotech corn technology, and since the study wanted to analyze their decision-making process on the biotech ban, the CDM was chosen. This model provides a linear, cognitive map regarding a person's decision-making stages and the factors influencing those stages. Upon exposure to a stimulus and after accepting that the information is deemed relevant to an adopter's wants and needs, this triggers a need recognition stage where a difference between an actual and alternative state is recognized. After a need is established, the search stage will be activated where an adopter evaluates his/her knowledge of the two states. Next, the pre-purchase evaluation of alternatives stage will occur where an adopter gauges the level of benefit derived from each state, which then leads to the purchase stage where the likelihood to purchase or subscribe to a certain state is evaluated. The adopter will then decide if he/she will continue to subscribe to the current state or go for the alternative state (consumption/adoption stage). Lastly, the adopter can choose whether he/she will recycle, dispose, or promote the chosen

state (post-consumption/adoption evaluation and divestment stage). It is also assumed that each decision-making stage is influenced by internal and external factors. These decision-making stages and influential factors were contextualized into farmer-specific variables and were used to understand the perceptions and attitudes of farmers on the biotech ban (Table 1).

Table 1. Contextualized decision-making stages and influential factors that were used in the study based on the Consumer Decision Model.

Consumer Decision Model (CDM) Variables	Contextualized Variables Used in the Study
Decision-making stages	**Decision-making stages of biotech corn farmers**
Need recognition stage	Desirability to plant alternative types of crops
Search stage	Level of familiarity and knowledge of biotech and non-biotech crops
Pre-purchase evaluation of alternatives stage	Level of benefit derived from biotech corn
Purchase stage	Likelihood to buy biotech corn seeds
Consumption/adoption stage	Desire to continue planting biotech corn
Post-consumption/adoption evaluation and divestment stage	Likelihood to sell and promote biotech corn
Individual differences	**Internal influential factors relative to current farming method**
Consumer resources	Time
	Capital
	Sources of information about biotech corn
Knowledge	Knowledge about biotech corn
	Knowledge about planting practices of biotech corn
	Knowledge about the requirements needed to plant biotech corn
	Knowledge about news on biotech corn (e.g., TV news and newspaper reports)
	Knowledge about the ban on planting biotech corn and *Bt* eggplant
Attitudes	Attitude towards planting biotech corn
	Attitude towards positive effects of biotech corn on environment and health
	Attitude towards the negative effects of biotech corn on environment and health
Motivation and involvement	Benefits of planting biotech corn
	Satisfaction in planting biotech corn
Personality, Values, and Lifestyle	Personal experiences in planting biotech corn
	Usage of income from biotech corn
Environmental influences	**External influential factors relative to current farming method**
Culture	Beliefs on acceptability of biotech corn
	Beliefs on acceptability of biotech corn in barangay or province
Social interactions	Experiences of co-farmers in planting biotech corn
Personal influences	Personal information regarding planting and purchasing biotech corn seeds
Family	Support of family in planting biotech corn
	Perception or opinion of family regarding biotech corn
Situation	Situation of co-farmers who are planting biotech corn
	Situation of economic demand of biotech corn in the market
	Situation after planting biotech corn

Each of the decision-making stages was framed as successive questions to mimic the CDM process and had a corresponding 5-point rating scale to measure farmers' responses. The desire to continue planting biotech corn was measured using a 3-point rating scale (i.e., 1 = will not continue adoption, 2 = unsure, 3 = will continue adoption). The ban perception was also measured using a 3-point rating scale (i.e., 1 = implementing the ban was an incorrect decision, 2 = unsure whether implementing the ban was correct or not, and 3 = implementing the ban was a correct decision). In terms of the influential factors, every farmer was asked how influential each variable was on their biotech farming practice using a 5-point rating scale (i.e., 1 = not at all influential, 2 = slightly influential, 3 = somewhat influential, 4 = very influential, and 5 = extremely influential). The stimulus used was a laymanized summary of the biotech ban issued by the Supreme Court. Qualitative data were also gathered during the interviews to verify all the answers given and were used for the thematic analysis in this paper.

This paper will mainly focus on analyzing the perceptions and attitudes of farmers towards the ban on biotech crops, in connection with their decision-making stages and influential factors. Data were analyzed using principal component analysis, Spearman correlation, correspondence analysis, and ordinal logistic regression in SPSS v.27. Model fitting was also performed to ensure that statistical assumptions are met. First, factor analysis was conducted to determine the underlying factors that tie the biotech corn farmers' common variables together. Next, the farmers' perceptions of the ban (the ban being correct or not) were modeled in the context of the 6 decision-making stages. Afterward, it was modeled against 24 influential factors affecting the decision-making of farmers. The narratives of farmers in the face-to-face interviews served as qualitative data to support the interpretation of research results.

3. Results

3.1. Socio-Demographic and Farm-Related Data of Biotech Corn Farmers in Pampanga

Out of the 111 biotech corn farmers in the study, there were a higher number of males than females, with a ratio of 93:7 (Table S1). This reinforces the traditional norm that farming is a male-dominated activity. Even though this is the case, it was seen that the wives of the male farmers played a significant role in the household decision-making, especially when it comes to income management for family expenses. Almost half of the farmers were between their middle adulthood and senior years, with 50 percent in the 45–64 age bracket. Interestingly, nearly one-third (27%) fell under the 65-and-above retirement age bracket, yet they were still active planters of biotech corn. The mean and median ages were 55 and 54, respectively. The youngest farmer was 24 years old and the oldest, 81. More than three-quarters of biotech corn farmers (89%) were married. More than half had access to primary-level education, with 51% having reached and/or completed elementary. Almost one-third (33%) had reached and/or completed high school, while less than one-tenth had reached and/or completed college or a vocational course. Most of them started farming at a young age since their parents handed down their farmlands to them. More than half (52%) had 1 to 5 members in the household, closely followed by 47 percent who had 6 to 11 household members. Most (66%) of them were affiliated with agricultural organizations. During the interviews, some of the farmers narrated how their organizational membership enhanced their biotech corn farming. According to them, their organization makes possible the practice of *bayanihan* or the spirit of communal unity, work, and cooperation, thereby enabling farmers to help one another in times of hardship. Furthermore, they meet regularly to discuss their harvest or other agricultural topics such as new farming methodologies and updates on their crops, among others.

Almost half (45%) have been planting biotech corn since it was approved for commercialization in 2003. This goes to show that many of the farmers included in the study are pioneers of the biotech corn technology in their respective municipalities. Almost all (97%) have a farm size of seven hectares and below, with an average size of 2.8 ha. This is similar to the findings of previous studies citing 2.7 ha [30], 2.17 ha [31], and 2.64 ha [3]

as the average farm size of biotech corn farmers. There were more (77%) lowland or plain areas allotted to biotech corn farming than those in the upland or mountainous areas (13%). A few (10%) farmers were planting biotech corn in both topographies. More than half (59%) of the farmers were farm owners, nearly one-third (26%) were tenants, and 15% were both owners and tenants. Based on their farm hectares and cropping season, a majority (73%) were earning Php 120,000 (~US$2290.27) at most by planting biotech corn during the dry season (based on the cost of biotech corn seeds, price of harvested biotech corn, and estimated expenses from farming biotech corn based on hectares and cropping season). Most of them stated that their main source of income is growing biotech corn, and emphasized how this crop increased their harvest and profit, thereby enabling them to pay their debts and support their family.

For the three municipalities, the usual practice was to buy and sell biotech corn from traders. According to a majority of farmers interviewed, traders often visit their barangays to sell biotech corn seeds and buy harvested biotech corn as well. The traders also offer loans to farmers who cannot afford to buy seeds in cash. Come harvest time, the charge for the seeds with corresponding interest will be deducted from the traders' overall payment for the produce. Looking at the bigger picture, traders serve as the farmers' middlemen, guaranteeing them a constant supply of biotech corn seeds and a regular buyer of their harvest. It is for this reason that most (74%) of the farmers purchase their biotech corn seeds from traders and a majority (84%) sell their harvest to traders as well. Meanwhile, less than one-third purchase or acquire their biotech corn seeds from seed companies (20%), cooperatives (18%), and town markets (11%). A few farmers purchase or acquire their seeds from barangay captains (4%), millers (4%), and agricultural technicians (2%). A few farmers also sell their biotech corn harvest to cooperatives (10%), town markets (8%), barangay captains (6%), and millers (5%). These numbers clearly show how the traders dominate the market channels of the farmers, thereby indicating their huge influence on the farmers' income and biotech corn adoption.

3.2. Biotech Corn Farmers' Perceived Correctness of the Ban on Biotech Crops

This study focused on exploring the decision-making process and various factors that may affect how farmers perceive the restrictive policy of banning biotech crops in the Philippines (2015 Supreme Court's Ban on biotech crops). Results of the survey indicated that among the 111 biotech corn farmers interviewed, 46% think that implementing the ban was an incorrect decision, and 35% indicated that implementing the ban was a correct decision, while the remaining 19% were unsure (Figure 2).

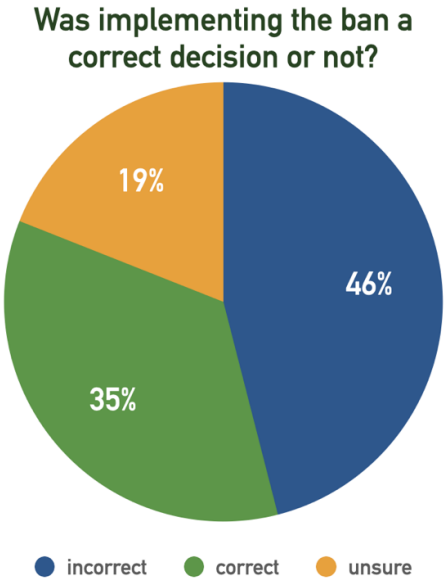

Figure 2. Biotech corn farmers' perceived correctness of the 2015 biotech ban.

In order to further understand the bifurcation among the farmers' responses, correspondence analysis and chi-square test were conducted between their ban perception and desire to continue biotech corn adoption (Figure 3). It was found that farmers who perceived the ban as incorrect would continue their adoption. Meanwhile, farmers who perceived the ban as correct were unsure whether they would continue their adoption or not.

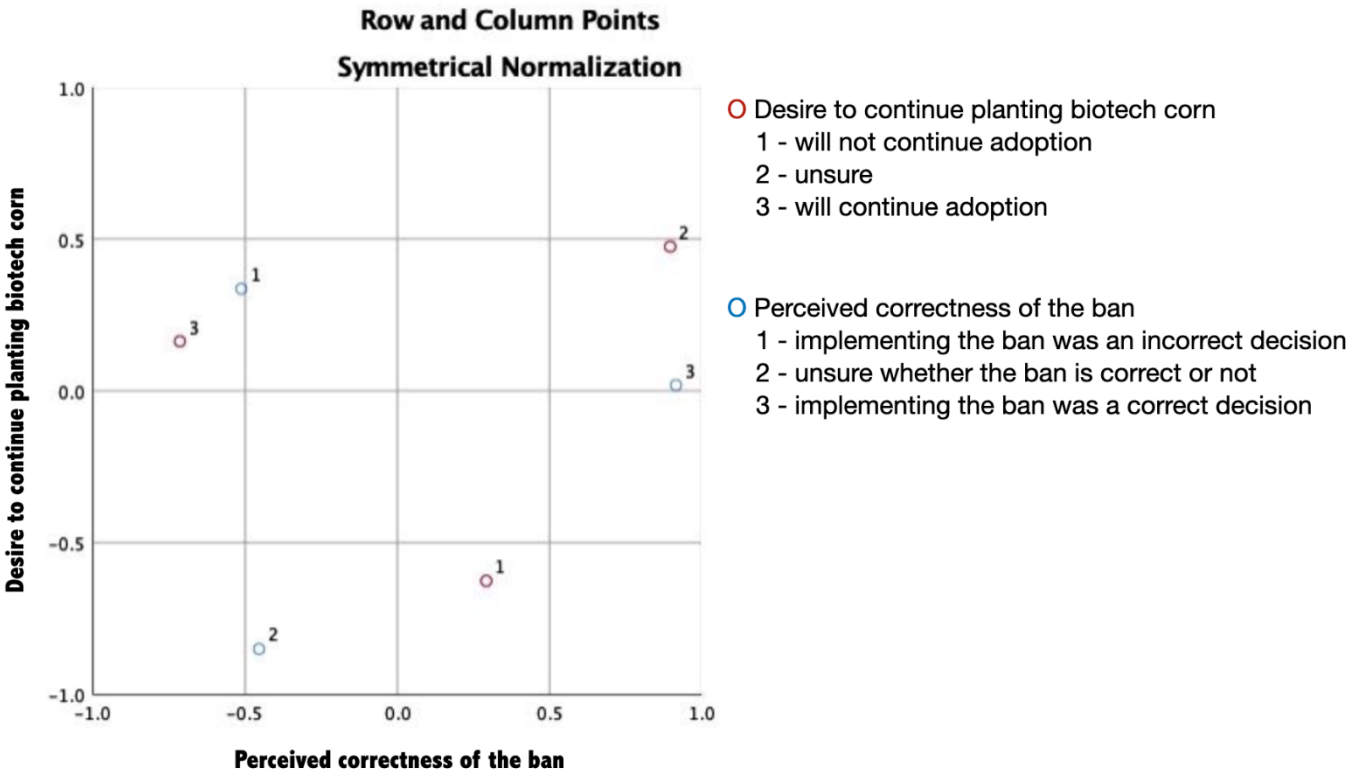

Figure 3. Correspondence analysis of farmers' perceived correctness of the biotech ban and desire to continue biotech corn adoption.

The bifurcation of the sampled group relative to perceived correctness of the ban may hint at the existence of possible factors that have induced different effects on individual farmers. Various internal influences (such as previous and current experiences and beliefs), as well as external influences (such as family, community, market situation, and local/national policy implementations), may affect an individual's perception. The succeeding sections deal with identifying the main factors influencing the farmers' perceptions and attitudes towards the ban.

3.3. Exploratory Factor Analysis of Candidate Influential Factors

A total of 30 variables were used in this study as predictors of farmers' perceived correctness of the ban. Of those, 6 variables comprise the decision-making stages, 16 variables represent internal factors, and 8 variables represent external factors. To determine how each of these variables relates to each other, an exploratory factor analysis was carried out (Table 2).

There were five latent factors that emerged. Most variables in Factor 1 coalesce to a common theme of outside influencers—co-farmers, family, and barangay/province—and were thus termed external factors. On the other hand, variables in Factor 2 correspond to internal influences and were referred to as internal factors. Variables in Factor 3 relate to farmer practices and gained experiences and were labeled farmer practices and experiences, while Factor 4 encompasses the decision-making stages and variables in Factor 5 as external knowledge sources.

Table 2. Exploratory factor analysis for all the variables used in the study.

Factor	Eigenvalue
Factor 1: External factors	
Beliefs on acceptability of biotech corn in barangay or province	0.747
Experiences of co-farmers in planting biotech corn	0.837
Personal information regarding planting and purchasing biotech corn seeds	0.412
Support of family in planting biotech corn	0.533
Perception or opinion of family regarding biotech corn	0.689
Situation of co-farmers who are planting biotech corn	0.769
Situation after planting biotech corn	0.486
Factor 2: Internal factors	
Benefits of planting biotech corn	0.667
Satisfaction in planting biotech corn	0.436
Personal experiences in planting biotech corn	0.439
Usage of income from biotech corn	0.686
Personal information regarding planting and purchasing biotech corn seeds	0.573
Situation of economic demand of biotech corn in the market	0.776
Situation after planting biotech corn	0.496
Factor 3: Farmer practices and experiences	
Sources of information about biotech corn	0.449
Knowledge about biotech corn	0.770
Knowledge about planting practices of biotech corn	0.702
Knowledge about the requirements needed to plant biotech corn	0.625
Attitude towards planting biotech corn	0.637
Factor 4: Decision-making stages	
Desirability to plant alternative types of crops	−0.744
Likelihood to buy biotech corn seeds	0.731
Desire to continue planting biotech corn	0.489
Likelihood to sell and promote biotech corn	0.604
Perceived correctness of the ban	−0.678
Factor 5: External knowledge sources	
Knowledge about news on biotech corn (e.g., TV news and newspaper reports)	0.426
Knowledge about the ban on planting biotech corn and *Bt* eggplant	0.756
Attitude towards positive effects of biotech corn on environment and health	0.456
Attitude towards the negative effects of biotech corn on the environment and health	0.805

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

Farmers who have are highly influenced by external factors (Factor 1) are more predisposed to be highly influenced by internal factors because of their situation after planting biotech corn, and personal information regarding planting and purchasing biotech corn seeds. External factors (Factor 1) are strongly correlated with the experiences and situations of co-farmers in planting biotech corn, and the acceptability of biotech corn in barangay or province, which shows that aside from economic considerations, farmers also accord high importance to their fellow farmers and communities with regard to the crop they are collectively planting. Meanwhile, internal factors (Factor 2) are strongly correlated with the situation of economic demand of biotech corn in the market. Farmer practices and experiences (Factor 3) are strongly correlated with knowledge about biotech corn and planting practices of biotech corn, thereby emphasizing that farmers accord high importance to fully knowing and understanding their crop and how it affects their farming practice. In addition, the decision-making stages (Factor 4) have an inverse relationship with the first stage of decision-making (desirability to plant alternative types of crops) and the farmers' perceived correctness of the ban. Lastly, external knowledge sources (Factor 5) are strongly correlated with the farmers' knowledge about the ban on planting biotech corn and *Bt* eggplant and attitude towards the negative effects of

biotech corn on the environment and health (which were stated in the ban but were eventually disproven by scientists and major scientific organizations worldwide based on published scientific data regarding biotech crops).

3.4. Relationship of Decision-Making Stages with Perceived Correctness of the Ban

To determine the effects of the farmers' decision-making stages on perceived correctness of the ban, a Spearman correlation was conducted (Table 3). All the stages emerged to be significant and were related to the farmers' perceived correctness of the ban, except for Stage 2 (level of familiarity and knowledge of biotech and non-biotech crops).

Table 3. Spearman correlation of decision-making stages and farmers' perceived correctness of the ban.

Variable	Estimate	Significance
Desirability to plant alternative types of crops	0.359 **	0.000
Level of familiarity and knowledge of biotech and non-biotech crops	0.015	0.873
Level of benefit derived from biotech corn	−0.211 *	0.026
Likelihood to buy biotech corn seeds	−0.375 **	0.000
Desire to continue planting biotech corn	−0.359 **	0.000
Likelihood to sell and promote biotech corn	−0.300 **	0.001

* significant at $p < 0.05$ level; ** significant at the $p < 0.01$.

3.5. Relationship of Internal and External Factors with Perceived Correctness of the Ban

To further understand which factors affect farmers' ban perception, the 24 pre-identified influential factors were used as predictors in an ordinal regression model (Table 4). Among the internal factors, capital, knowledge about the requirements needed to plant biotech corn, attitude towards the negative effects of biotech corn on the environment and health, satisfaction in planting biotech corn, and usage of income from biotech corn were found to have significant effects towards farmers' ban perception. Most of the variables here fall within the latent internal factors (Factor 2) and farmer practices and experiences (Factor 3) in the previous exploratory factor analysis. Individual farmer profile characteristics have been identified in earlier studies to affect farmer participation in agricultural policies [32]. Meanwhile, personal information regarding planting and purchasing biotech corn seeds, support of family in planting biotech corn, and perception or opinion of family regarding biotech corn were external factors that have significant effects on the farmers' ban perception. All of these identified significant factors fall within the latent factor of external factors (Factor 1) in the factor analysis, which shows a good alignment between the two analyses conducted. These external factors are consistent with previous studies on farmer participation in agricultural policies [32,33]; however, the alignment between the conclusions of these previous studies are not straightforward [34,35]. Thus, context-specific details are highlighted as an important factor in understanding policy support [32].

Table 4. Ordinal regression [a] to determine the relationship of internal and external factors to farmers' perceived correctness of the Supreme Court's Ban on biotech crops.

Variable	Estimate	Odds Ratio	Significance
Internal Factors			
Time	−0.593	180.94%	0.101
Capital	1.003	36.68%	0.008 **
Sources of information about biotech corn	−0.354	142.48%	0.251
Knowledge about biotech corn	0.554	57.46%	0.163
Knowledge about planting practices of biotech corn	−0.77	215.98%	0.057
Knowledge about the requirements needed to plant biotech corn	−0.954	259.61%	0.011 **
Knowledge about news on biotech corn (e.g., TV news and newspaper reports)	−0.41	150.68%	0.098
Knowledge about the ban on planting biotech corn and *Bt* eggplant	−0.104	110.96%	0.624
Attitude towards biotech corn	−0.163	117.70%	0.622
Attitude towards positive effects of biotech corn on environment and health	−0.345	141.20%	0.161
Attitude towards the negative effects of biotech corn on the environment and health	0.944	38.91%	0.005 **
Benefits of planting biotech corn (e.g., increase in income)	0.499	60.71%	0.185
Satisfaction in planting biotech corn	−1.517	455.85%	0.004 **
Personal experiences in planting biotech corn	−0.342	140.78%	0.325
Beliefs regarding acceptability of biotech corn	−0.149	116.07%	0.595
Usage of income from biotech corn	1.379	25.18%	0.006 **
External Factors			
Acceptability of biotech corn in barangay or province	0.612	54.23%	0.103
Experiences of co-farmers in planting biotech corn	−0.04	104.08%	0.917
Personal information regarding planting and purchasing biotech corn seeds	1.232	29.17%	0.017 **
Support of family in planting biotech corn	−0.775	217.06%	0.047 *
Perception or opinion of family regarding biotech corn	−0.852	234.43%	0.037 *
Situation of co-farmers who are planting biotech corn	−0.382	146.52%	0.212
Situation of economic demand of biotech corn in the market	−0.489	163.07%	0.075
Situation after planting biotech corn	0.224	79.93%	0.523

* significant at $p < 0.05$ level; ** significant at the $p < 0.01$. [a] Link function: Cauchit: $\tan(\pi(F_k(x_i) - 0.5))$ Psuedo R-squared: Cox & Snell: 0.316; Nagerlike: 0.361; McFadden: 0.183 Test of parallel lines: Chi-square = 8.876, df = 24, sig = 0.998 Model fit: Chi-square = 42.191, df = 24, sig = 0.012.

4. Discussion

The Philippines is one of the frontrunners of agricultural biotechnology in Southeast Asia, having been the first Asian country to approve the cultivation and commercialization of two important genetically engineered crops (*Bt* corn in December 2002 and Golden Rice in July 2021). The Philippines also approved *Bt* eggplant—another genetically engineered crop first planted in Bangladesh that has brought benefits to many farmers and consumers—in July 2021 for food, feed, and processing. These recent approvals did not have a precedent in the years prior to 2020. In fact, the Philippine Supreme Court (SC) issued a ban on cultivating biotech crops in December 2015, but it was eventually lifted in July 2016, not even a year after its implementation, because of appeals from scientists and scientific organizations worldwide. One of the most important matters that need to be considered is how the primary adopters of biotech crops perceive this ban and how this would affect their future biotech crop adoption. This paper contributes to this issue by analyzing the perception and attitude of Filipino biotech corn farmers on the biotech ban.

4.1. Two Major Themes of Farmer Perception on the Ban: Livelihood Sustainability versus Law Abidance

Almost half (46%) of the biotech corn farmers answered that implementing the ban was an incorrect decision. A common reason that these farmers disagree with the SC's decision is that they have been planting biotech crops for more than a decade and they have not seen or felt any negative effects on their health and environment. It is also for this reason that a lot of the biotech corn farmers are seeking evidence from the government first before they believe and adhere to the ban. They are also saying that planting biotech corn is their number one source of income, from which they have reaped higher yields than the white corn they were planting previously; thus, stripping this crop from them and other rural communities in their province would have negative consequences on their lives. The farmers also emphasized that planting biotech corn is less laborious, and it has significantly reduced their pesticide application; hence, they are appealing for the government to provide alternative programs or other high-yielding crops applicable to their situation if the ban on biotech crops will persist. The following testimonials reflect the farmers' perspectives:

> *"The government will not subsidize the losses that we will suffer when we shift to non-biotech corn. The technicians have studied this crop, and we believe in what they advise because we can see for ourselves the good harvest it brings".*

> *"I continued to plant biotech corn because the government did not give any alternative seeds to sow, so we have no choice in the matter".*

> *"I have no choice but to plant biotech corn. If I switch to an alternative crop, all the pests will come to my farmland and my crops will get destroyed".*

Lastly, since the farmers think that they have the most direct experience in using and handling biotech corn, they strongly feel that they should be involved during the initial stages of any policy framing that involves this agricultural technology. They felt wrongly treated for being left out when they are the number one adopters of this biotech crop. For the 19% who were unsure whether the ban was correct or not, they are torn on whether they should adhere to the law or maintain the good livelihood they are experiencing with biotech corn. However, it is apparent from their interviews that they are also appealing to the government to provide an alternative crop that can match the high standards set by biotech corn. On the other hand, 35% indicated that implementing the ban was a correct decision. A common theme for these farmers is their desire to follow the law and their trust in the SC's decision. They believe that the government has done the necessary research and legal procedures before implementing the ban. However, many of the farmers are still voicing their appeal to government leaders for an alternative crop that can match the high standards set by biotech corn in their province. They were also saying that they will continue to plant biotech corn if seeds are still available:

> *"If biotech corn is still available in the market, we will still plant it; but if we can no longer find retailers/sellers for it, then we will stop planting".*

Based on the correspondence analysis, farmers who perceive the ban as incorrect would continue their adoption, whereas farmers who perceive the ban as correct were unsure whether they would continue their adoption or not. This indicates that even farmers who want to abide by the law as discussed earlier are not fully decided on whether to completely stop their biotech corn adoption. This bifurcation of farmers' perceived correctness of the ban shows an interesting take regarding how compliance and attitudinal change happen among farmers when a restrictive agricultural policy is implemented. To understand this better, we next sought to understand the farmers' decision-making process pertaining to the ban and the main factors which affected their decision-making.

4.2. Farmers' Decision-Making Process and Factors Affecting Farmers' Ban Perception

The first stage of decision-making in CDM (i.e., the needs recognition stage) compares an adopter's current situation with an alternative state usually encountered in the environment. Oftentimes, this falls within the first impression type of perception which may or may not affect individuals, depending on their thought process. This was termed "automatic processing" since needs recognition is attributed to an individual's subconscious level [36]. Here, the farmers' current state is biotech corn farming, and the alternative state is the adoption of non-biotech farming. It was found that the biotech corn farmers' desire to plant alternative crops is directly related to their ban perception, such that farmers who have expressed a higher desire to try planting non-biotech crops perceive the ban as being a correct policy implementation, while those who expressed low levels of desire to try planting non-biotech crops perceive the ban as an incorrect policy. This is clearly shown in the heat diagram (Figure 4) which was generated from the Spearman correlation analysis in Table 3. Correlation estimates were transformed into a color value based on a two-color gradient with green representing increasing magnitude of negative relationship and red representing increasing magnitude of positive relationship. The separation in the distribution of the farmers in terms of ban perception is consistent with this result.

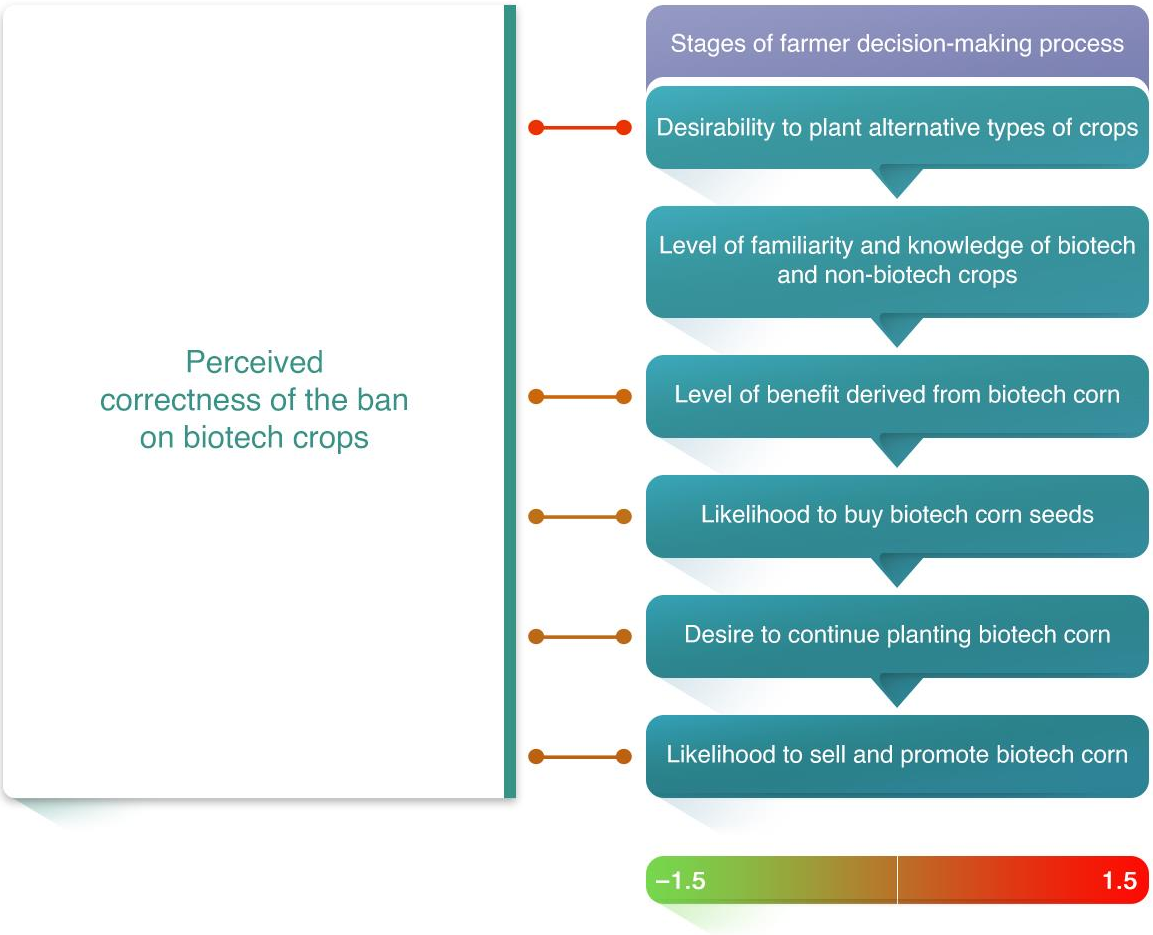

Figure 4. Heat diagram of the biotech corn farmers' decision-making stages and their ban perception.

In terms of compliance, farmers who adhere to the law regardless of their personal satisfaction, beliefs, and experiences, and exhibit a positive attitude towards the ban conform to the moral picture described in the Deterrence Theory [13]. The level of punishment also greatly affects people's compliance with the law. In this case, there was no actual penalty enforced by the law for biotech farmers who did not abide by the biotech ban, which may have greatly influenced the farmers' decision to continue adoption despite a

nationwide planting restriction. Meanwhile, in terms of mental processing of persuasion and attitude change, two routes are presented in the Elaboration Likelihood Model (ELM). Farmers who exhibit bottom-up thinking or objective elaboration are those who value their past experiences, satisfaction, and beliefs. These farmers rationalize external and internal inputs (such as knowledge of the ban) and tend to ascribe lower priority to first impressions or suggestions from credible information sources. On the other hand, farmers who exhibit top-down thinking or biased elaboration highly value inputs from credible sources and tend to prioritize this over other factors. This bifurcation of the population therefore leads to the formation of the dominance of extreme answers relative to their perception of the correctness of the ban, such that bottom-up thinkers (i.e., objective elaborators) are predisposed to think that the ban is incorrect, whereas top-down thinkers (i.e., subjective elaborators) indicate that the ban is correct.

An inverse relationship can be observed between the farmers' ban perception and each of the succeeding stages of pre-purchase evaluation (level of benefit derived from biotech corn), purchase (likelihood to buy biotech corn seeds), adoption (desire to continue planting biotech corn), and post-adoption evaluation and divestment (likelihood to sell and promote biotech corn) (Figure 4). When farmers perceive the ban as incorrect, they are more likely to ascribe positive values to the benefits they derive from biotech corn and the continued purchase, adoption, selling, and promotion of this crop. This indicates that the farmers' level of benefit from, and satisfaction with biotech corn is the primary driver of their perception of a restrictive ban that has the potential to affect their livelihood. Indeed, such dispositional behavioral factors affecting the adoption of agricultural policies have been reported previously [33,34].

In the theory of cost–benefit analysis, decisions are evaluated based on their consequences. Based on the data of this study, there are three main benefits to adopting biotech corn since 2002. First, the economic aspect: farmers generally earn US$2290.27 from planting biotech corn during the dry season. They were able to achieve this due to the innate resistance of biotech corn to major pests, thus translating to an increase in yields and less pesticide application. They also said that this income is comparably higher than the income they earn from planting white corn, which they also reported to be consistently eaten by pests when they were still planting it in the past. Second, the social aspect: almost all the farmers reported that aside from the increase in income, they were able to see the positive impact of biotech corn adoption within their rural communities. Based on the farmer interviews, these came in the form of improved houses as well as better access to education and healthcare. Furthermore, the reduction in labor allowed the aging farmers to continue working on the farm. Indeed, there is a direct relationship between the number of years planting biotech corn and the farmers' ban perception (Table S2), which means that the longer these farmers have been growing biotech corn, the more they will perceive the ban as incorrect. This sustained improvement within their social group is also one of the major reasons that biotech corn adoption is a success story among these farmers. Third, the environmental aspect: since biotech crops such as biotech corn reduce pesticide application, this also significantly reduces GHG emissions, as evidenced in previous studies [37–39]. These benefits comprise the three pillars of sustainable agriculture. Meanwhile, the costs of non-adoption as a result of the ban would also translate to three major consequences. The farmers' major source of income and livelihood would be disrupted, which would then result in a lack of resources for individual and social improvement, and a potential increase in pesticide application again. This cost–benefit analysis shows why most of the decision-making stages had an inverse relationship with their ban perception and why most farmers would want to continue biotech corn adoption despite a nationwide planting restriction. A recent study that conducted a risk–benefit analysis of genetically modified food also concluded that the economic, environmental, and health benefits definitely outweigh the costs; hence, biotech crops should be more accepted by the public, and phobias related to genetically modified organisms should be dispelled [40].

While the decision-making process of the farmers regarding the ban has been clarified, it is also important to understand the factors which affected their ban perception. A heat diagram was also generated based on the ordinal regression in Table 4 to clearly show the positive and negative relationships between the significant influential factors and the farmers' perceived correctness of the ban (Figure 5). Regression estimates were transformed into color values in a similar fashion as Figure 4. The results of the factor analysis and ordinal regression strongly aligned with each other and can be grouped into two major themes: the internal and external influential factors. For the internal factors, capital, income, and attitude towards the negative effects of biotech corn on the environment and health (as indicated in the ban) have a positive relationship with the farmers' ban perception, which means that when farmers highly value these factors, they are more likely to perceive the ban as correct. Since capital and income are very important for farmers, most especially in developing countries, maintaining their jobs is considered a top priority, which may be the reason that these variables have a direct relationship with ban perception. However, as seen in the correspondence analysis, farmers who perceive the ban as correct are not fully decided on whether to stop their adoption. This is because their biotech corn adoption yields three major benefits, the most important of which are the increase in yields and income. Meanwhile, the information provided in the ban pertaining to the safety of biotech crops on the environment and health was seen as a factor that leads to a positive ban perception. Even though this is the case, many farmers emphasize that they have been adopting biotech corn for a long time and they have never seen or felt any negative effects on their health and environment, as evidenced in the following testimonials:

> *"The health issues which they use as a basis for banning biotech corn are unfounded. The current trend in agriculture is continued research to help the farmers, so we should use the technology available".*

> *"The government should provide concrete evidence on why they are banning biotech corn and other biotech crops. If they can really prove that biotech corn is harmful to our health and the environment, then that is only the time to ban it in our country".*

Furthermore, major scientific organizations worldwide have attested to the safety of biotech crops. The National Academy of Sciences (Washington DC) reported that "there is no difference between traditional and biotech crops in terms of risks to human health, nor any negative effects on the environment" [41]. In a survey conducted by the European Union that covered 900 reports on research pertaining to the impact of biotech crops on human health, it was also reported that they are no more risky than conventional breeding techniques [42]. These refer to the substantial equivalence of biotech crops, which means that they are as safe and effective as their conventional crop counterparts. Taken together, the reports of these major scientific organizations and biotech farmers' testimonials highlight the safety of biotech crops and that the ban had no concrete scientific basis. On the other side of internal factors, knowledge about the requirements needed to plant biotech corn and satisfaction in planting biotech corn have an inverse relationship to farmers' ban perception. This means that when biotech corn farmers highly value these factors, they are more likely to perceive the ban as incorrect. The results of the correspondence analysis concur with this since farmers who perceive the ban as incorrect are more inclined to continue their biotech corn adoption. Indeed, previous studies on biotech farmers emphasized the importance of knowledge and satisfaction for continued adoption [27,28].

Figure 5. Heat diagram of significant internal and external factors with the farmers' ban perception.

For the external factors, farmers who highly value their personal information regarding planting and purchasing biotech corn seeds are more likely to perceive the ban as correct. In the CDM, this factor falls under the category of personal influences, which means that the behaviors of farmers are affected by those they closely associate with [29]. Furthermore, they will respond to the perceived pressure of conforming to norms and expectations provided by their immediate community. In the context of the study, the personal influences of biotech corn farmers when it comes to their farming practices are their co-farmers, farmer leaders, and agricultural technicians, which are also called reference groups in the CDM. The perceived pressure to conform to the law based on what these reference groups are thinking may have been one of the major reasons that this factor emerged as critical in their ban perception. On the other hand, farmers who highly value the support and perception/opinion of family regarding biotech corn are more likely to perceive the ban as incorrect. In this study, 89% of farmers are married and 47% had 6 to 11 household members. As breadwinners, these farmers prioritize the income they are obtaining from planting biotech corn to support their families. Hence, it is not surprising that farmers who highly value their families will perceive the ban as incorrect, as evidenced by the following testimonial:

> *"I benefit a lot from biotech corn. The money I provide to my family mainly comes from the biotech corn that I sell".*

5. Conclusions and Recommendations

As the prime stakeholders in the agribiotech industry, biotech farmers' perspectives are a valuable source of information regarding policy changes and strategies, market situation, and societal impacts. Had the 2015 Philippine Supreme Court ban on biotech crops persisted, severe impacts on farmers' quality of life and income are anticipated and thereby prompt research initiatives targeting key interactions among factors affecting farmer perspectives and decision-making. Results from this analysis have highlighted the critical importance of farmer consultations in policy framing and implementation to avoid

conflicts and farmer indifference. Indeed, farmer involvement in policy framing has proven to be a valuable piece of information [43,44].

This paper determined the relationship between the biotech corn farmers' decision-making stages and the perceived correctness of the ban. While farmers' perspectives at the initial stage of decision-making (need recognition stage) appear to separate the farmers into two distinct groups, the succeeding decision-making stages show otherwise. This hints at the resistive behavior among biotech corn farmers towards restrictive agricultural policies, more specifically towards the Supreme Court's ban on biotech crops. This, therefore, confirms the pragmatic nature of biotech corn farmers [27]. Taken together, it is shown that within the context of the 2015 Philippine Supreme Court's ban on biotech crops, biotech corn farmers thus have significant influences from their decision-making stages, internal factors, and external factors. A summative heat diagram was generated to illustrate all the significant decision-making stages and influential factors and their positive or negative interactions with the farmers' ban perception. (Figure 6). The dilemma of choosing whether to abide by the law or to sustain their livelihood is apparent in the results of this paper. The paper has also highlighted the importance of analyzing restrictive agricultural policies through different theoretical lenses which can explain the concepts of deterrence, compliance, persuasion, and cost–benefit analysis. This approach can potentially extend to future studies focusing on restrictive policies. Furthermore, the findings of this paper could be a pivotal source of information for farmer-informed data regarding agricultural policy support and product adoption. This, therefore, prompts immediate attention among policymakers and local government units who develop and improve agricultural policies regarding biotech crops, since the observed behavior among farmers may incite disagreements in policy implementations. Hence, better consultation and communication between farmers and policymakers should be carried out in future policy framing and implementation regarding biotech crops.

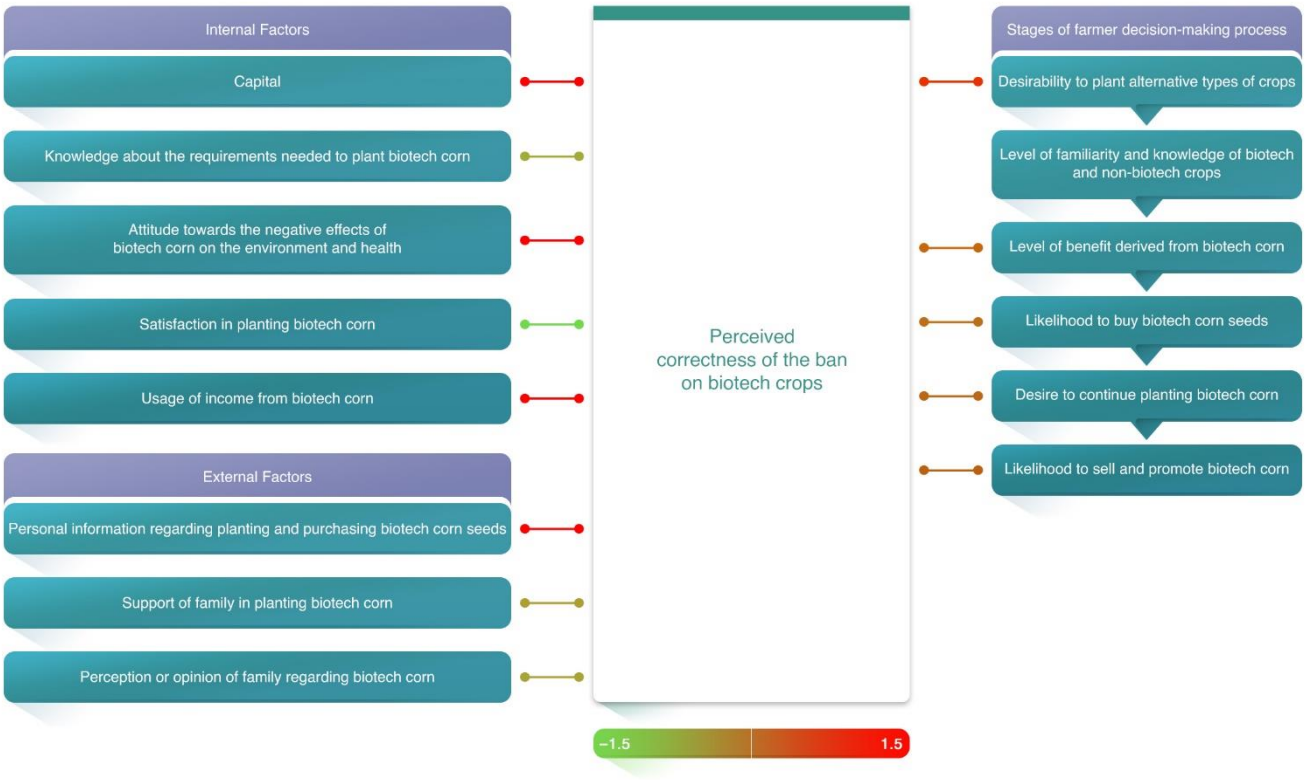

Figure 6. Integrated interaction map of significant internal and external factors (left), and decision-making stages (right) affecting farmers' ban perception.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su14137919/s1. Table S1: Socio-demographic and farm-related data of the sampled biotech corn farmers in Pampanga, Philippines; Table S2: Spearman correlation of socio-demographic and farm-related data with farmers' perceived correctness of the ban.

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