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Genetically Modified Organisms : A case study on Bt Corn in the Philippines

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Genetically Modified Organisms: A case study on Bt Corn in the Philippines

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Table of Contents

List of Figures

List of Tables

I. Introduction

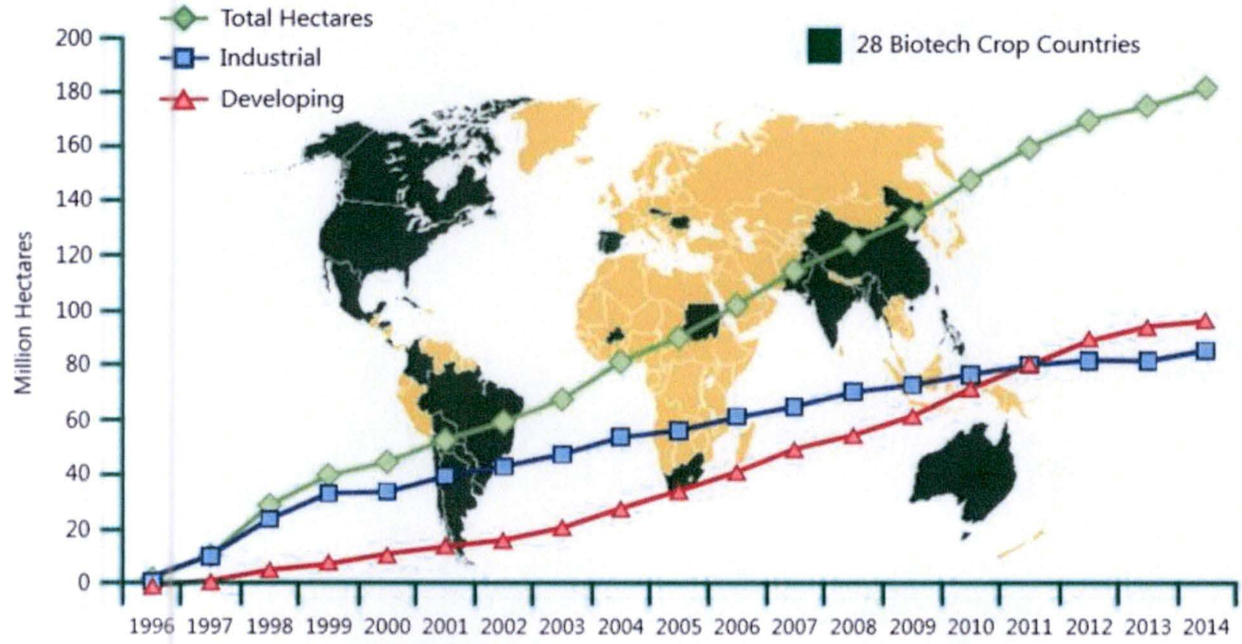
Opinions on GMOs are split into two: those who support it and those who are against it. The supporters argue that it should be used everywhere to help small and large farmers increase their yield and profit per hectare whereas the opponents fear its possible implications on the monopolization of the industry, human and animal health, and biodiversity. This paper's main objective is to dive into the debate on GMOs and to find the arguments of each side. It also aims to see to what extent GMOs have been assessed in theoretical and empirical literature. To complement those, a case study on the Philippines is prepared; to know if the claims of proponents and opponents of GMOs have validity in context.

The next sections of this paper are divided into 4. Section 2 looks at the history of GMO crops, theoretical and empirical evidences on GMOs that are available on the web. GoogleScholar, Jstor, and ScienceDirect are some of the web sources consulted on the studies already published. These would show what has already been done to assess GMOs in order to correctly judge whether GMOs are "good" or "bad". The literature review can also show the gaps, such as, what still has to be measured and tested. Section 3 contains an in-depth discussion of the Philippine experience on Bt corn with a special focus on Bukidnon province using secondary data and conducted interviews. Section 4 blends the developed arguments for or against the use of GMOs from the earlier 2 sections and transforms it into potential costs, potential benefits and potential risks of using GMOs. And then, it would be analyzed qualitatively. Section 5 contains the conclusions of this research and suggestions for future research.

II. The rise of Genetically Modified Crops

Genetically modified organisms refer to the introduction of new genes to traditional crops and animals among other things. The genes introduced to the animals or crops do not necessarily have to come from the same species or other species but could also come from a completely unrelated organism (Qaim, 2009). GMOs are also called biotech, genetically engineered (GE) or transgenic. Others would prefer not to use the term GMOs because all crop plants even animals were genetically modified from their wild state (Reid, 2006). And so, in this paper, GMOs, biotech, GE or transgenic will be used interchangeably and they would all refer to the same thing. The primary goal of crop modification is to help protect the crop against viruses, pests and weeds, to increase food production and to reduce input use. The first ever traits developed for crops were insect resistance and herbicide tolerance. Those plants are able to deflect insects and weeds without the farmer's application of pesticides and herbicides, respectively. In 1983, tobacco was the first crop to be genetically modified by making it resistant to the Cucumber Mosaic Virus in China (Yang and Chen, 2015 and James and Krattiger, 1996). USA and France were the first to conduct field trials on tobacco in 1986 and on 56 other transgenic crops. Most of the field trials conducted in those times were on corn, canola, tomato, potato and soybean. In 1992, transgenic crops were first commercialized in China, specifically the tobacco and a virus resistant tomato. Alongside China, USA was the first industrialized country to have approval from the Food and Drug Administration (FDA) of the commercial sale of a transgenic tomato (with delayed ripening) for food use in 1994. By 1995, the traits most approved for commercial use are herbicide resistance, insect resistance and delayed ripening. There were also 35 transgenic crops approved for commercial use on the same year. These approvals were facilitated by the efficiency of the well-organized regulatory biosafety agencies established in the respective countries (James and Krattiger, 1996). Eventually, developments in the field of science allowed for other crop modifications to arise, such as, the Roundup Ready (RR) soybean introduced by Monsanto in 1996 and years later RR cotton, maize and other crops also made their debut (Wilkerson, 2015). This modification protects the crops from the negative effects of the herbicide Roundup, allowing the crop to maintain the same yield level while killing the weed.

Figure 2.1
Global Area of Biotech Crops
1994-2014



Source: Figure adapted from ISAAA, James (2014)

By 2014, GM crops were planted in 28 biotech crop countries for over 181.5 million hectares of land after 19 years of commercialization. The top adopting countries are United States of America, Brazil, Argentina, India and Canada. Other countries that have adopted are China, Paraguay, Pakistan, South Africa, Uruguay, Bolivia, Philippines, Australia, Burkina Faso, Myanmar, Mexico, Spain, Colombia, Sudan, Honduras, Chile, Portugal, Cuba, Czech Republic, Romania, Slovakia, Costa Rica and Bangladesh, a total of 28 biotech countries. 19 out of the 28 countries are growing biotech crops in 50,000 hectares of land or more. Vietnam and Indonesia were added to the list of adopting countries by 2015 while Cameroon, Egypt, Ghana, Kenya, Malawi, Nigeria and Uganda are conducting field trials on certain crops to determine which ones to adopt (James, 2014). The increasing and widespread adoption are signs that countries are welcoming transgenic crops in their respective agriculture sectors. The most common genetically engineered crops and has the largest number of approvals worldwide are varieties of soybean, canola, potato, cotton and corn (Reid, 2006 and James, 2014). USA continues to lead the production of biotech crops globally with 73.1 million hectares (40% share of the global) and it has the highest biotech hectarage increase in 2014. Brazil runs second to USA with 42.2 million hectares of land devoted biotech crops and Canada is ranked third with 11.6 million hectares. Interestingly, developing countries have more hectarage devoted to biotech crops than industrialized countries for the third consecutive year (James, 2014).

At the end of October 2014, a total of 38 countries have granted regulatory approvals to use biotech crops for food, feed or for environmental release since its commercialization in 1994. Because of the fast development and adoption of biotech crops, its global value for seeds alone reached USD 15.7 billion (James, 2014). In the same report, it also says that biotech crops were able to contribute to food security, sustainability and climate change by increasing crop production, providing a better environment through the reduction of pesticide use, conserving biodiversity by saving 132 million hectares of land from conversion, and helped alleviate poverty by helping 16.5million farmers and their families. Biotech crops contribute to a *sustainable intensification* strategy, which is allowing production to increase using the same amount of land; this is favored by many science academies because it saves and maintains forests and biodiversity (James, 2014). Basically, land productivity increases with the use of biotech crops and it produces a number of positive externalities.

Currently, there are four known categories of GMOs - nutritional improvement, stress tolerance, enhanced shelf life and pharmaceutical or industrial modification. Kamthan, Chaudhuri, Kamthan M., and Datta (2016) define the first three main categories. First, crops could be modified by enriching it with nutrients, increasing the proportion of existing nutrients or decreasing/eliminating the anti-nutrients/toxins. For example, the introduction of a quality trait beta-carotene (vitamin A) in Golden rice. Second, crops could also be enhanced to withstand more abiotic stresses like salinity, pests, drought, flood and extreme temperatures so that the yield would not be severely reduced. It aims to reduce a farmer's herbicide or pesticide use which affect his health adversely. Such transgenic crops could be substituted by the farmers for insecticide or pesticide use (Qaim 2009). Thirdly, scientists also introduced traits that extend the crops' shelf-life and/or delay ripening (Kamthan, et al., 2016). Fruits and vegetables will take longer before they rot and this helps ensure a country's food availability. Qaim (2009) defines the fourth category wherein genetic modification would allow crops to produce special substances for pharmaceutical or industrial purposes.

Given these good qualities and objectives of transgenic crops, it seems that the world would accept it with arms open wide but it did not. There are a lot of debates going on with scientists, seed corporations, governments, non-government organizations, farmers and civil society organizations. The main reason for the division are the uncertain impacts on health and environment, small farmer profits, bargaining power and seed companies' monopoly power.

Those that support transgenic crops are the companies that produce the seeds, scientists and some governments. Monsanto, one of the pioneers and largest producers of GMOs, believes that by improving biotechnology and its practices they could double production of corn, soybeans, cotton and spring-planted canola (Monsanto, 2016). Supporters of GMOs argue that it would help ensure food security because of the farmer's higher crop yield. In addition, they argue that farmer profits would increase because of the lesser crop losses. Using transgenic crops increases crop yield because of the traits mentioned earlier. It is more protected from external agents (i.e. pests, extreme weathers, and chemicals) and so damage losses would decrease. As farmers have more productivity, given the same or even lesser costs, then their profits would be increasing.

The rise of GMO use, referred to by Evenson (2003) as the gene revolution, is complementary to the green revolution that occurred in the 1940s as it makes farmers potentially more productive due to the trait improvements on GM crops. More and more countries are adopting and using transgenic crops. To name a few: Philippines, Kenya and Japan declare all out support for bio-tech crops due to its capability to uplift food production and agriculture in their countries. As of 2015, 18 million farmers are benefiting from the use of these crops (ISAAA, 2015).

Those who argue against the use of GMOs believe that using it would pose possible problems on the environment because it could disrupt biodiversity. The European Union is highly protective and conservative against its use because of the uncertainty on the impacts it might have on the environment.

And so, they require a scientific assessment of the impacts to human and animal health and the environment before allowing the use of a certain GMO (EFSA, 2016).

The failure of introducing GE crops to small farmers arose because these farmers tend to save seeds from the harvest to plant for the next season which could not be done using GE crops, they call it the terminator gene. This has caused the farmers and NGOs to be upset about this inconvenience and reliance on the MNC for seeds and other inputs in order to produce (London and Hart, 2004). A similar notion is mentioned by Sharma (2004), that there is strong opposition to GMOs because of the potential monopolization of seed markets and exploitation of small farmers. There was mobilization in India, South Africa and Brazil initiated by different civil society organizations against the use of GE crops, those mostly manufactured by Monsanto. They did not approve of the market dominance and dependence of farmers to Monsanto for their seeds and other inputs and the terminator gene (Scoones, 2008). The high level of privatization in the rights of implementing and using it implies that the GM technology might not reach poor farmers (Azadi and Ho, 2010). The Coalition of Farmers Rights and Advocacy Against GMO's (COFAM) in Ghana believe that providing patent rights to plant breeders will give monopoly power to those companies under the guise of research and development in plant breeding. It will make the poorest farmers heavily dependent on expensive inputs which might increase indebtedness in face of unstable incomes. It also might kill the traditionally bred seeds which represents their independence and resilience (Kangmennaang, et al., 2016). Another issue is that majority of GM crops do not make higher yields and requires some optimal conditions which are not met by small-scale farmers (Azadi and Ho, 2010).

Moreover, the World Health Organization (WHO) exercises caution in promoting the use or consumption of GMOs due to three health risks: allergenicity, gene transfer and outcrossing, and environment risk. They also say that many genes used in GMOs have not been in the food supply before. It exposes the consumers, whether human or animals, to new genes that might have potential risks for human health and development (WHO, 2005). MASIPAG, a civil society organization in the Philippines, agrees to these health risks. They have conducted studies that show how farmers use of GM crops led them to use more chemical inputs increasing their exposure to carcinogens, poisons the land, water and human bodies. Traditional corn varieties were also contaminated by the GM corn giving difficulty to indigenous farmers in planting these (Masipag, 2016). They strongly believe that using GM crops makes the farmers powerless, poorer due to the increased chemical use, and threatens biodiversity.

The latter issues hinder the faster distribution of positive impacts on profits and the further improvement of GM technology. Non-acceptance slows down the process of improving it because they disallow testing or trials on fields and science cannot move forward and develop further without testing.

A. Theoretical Models

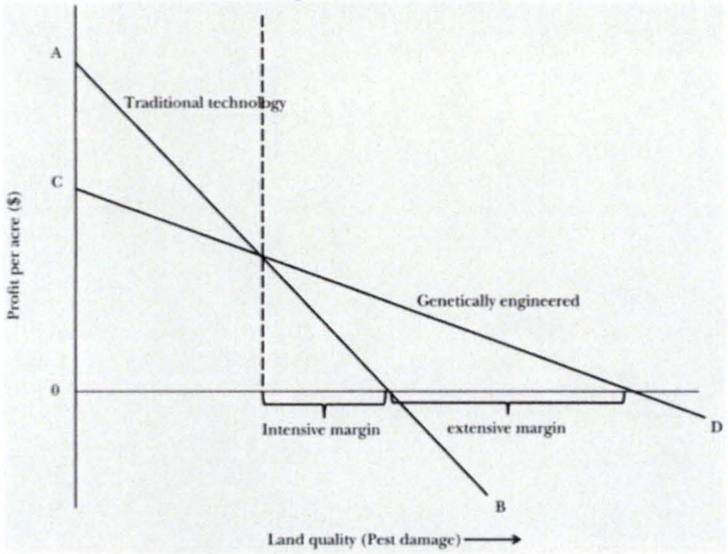
Damage Control Model

The damage control model of Barrows, Sexton and Zilberman (2014) describes the decision of farmers to use insect-resistant or herbicide-tolerant technology within the damage control framework of Lichtenberg and Zilberman (1986). This model shows an indirect enhancement of productivity through the introduction of a new technology. Farmer yield or output is defined as the product of potential output and the share of crop not damaged by pests. The reduction in pest damage could be mitigated through pesticide applications, agricultural biotechnology adoption, or other agricultural practices.

Hence, farmers that are more prone to pest problems without access to alternative damage control techniques are more likely to adopt GE crops because the pest pressure and damage are reduced, which in turn increases the farmer yield and profit per acre compared to non-adopters of the GE crops in the same context – keeping in mind, however, that these results occur *ceteris paribus*. It is also possible that GE crops replace the chemical applications which reduces the cost of damage control and thereby increasing farmer profit per acre. On the other hand, adopting GE crops in a context of low pest-pressure does not bring about much change in yield.

The graph on figure 2.2 shows the difference in production of traditional technology users, line segment AB, and genetically engineered technology (GE) users, line segment CD. As land quality decreases, or as pest damage increases, the profit per acre decreases for both traditional technology users and GE users. With low pest pressure or high land quality, the traditional technology users receive greater profits than GE users and this is found on the left side of the segmented vertical line. The cost of using GE crops is not compensated by the small improvement in yield in these areas. With high pest pressure or low land quality, the GE users receive greater profits than traditional technology users because the improvement in yield is greater and compensates more than the cost of GE seed. With sufficiently high pest-pressure, generating profits is only possible with GE crops because the losses with traditional technology are too great. This shows that GE adoption is better when the pest pressure is high because more benefits are generated along the intensive margin and extensive margin, where production became possible on land that was not productive prior to GE use.

Figure 2.2
Damage Control Model



Source: Barrows, Sexton and Zilberman (2014)

To illustrate, suppose there was a farmer in an environment with low pest pressure and he decides to adopt the Bt Cotton from the conventional cotton that he uses. He is willing to pay a higher rent for the Bt cotton seeds but will not find an increased cotton yield from the conventional cotton. It's because of the low pest pressure environment, even while using conventional cotton seeds he was not bothered by insects or pests that much and so after adopting Bt Cotton, his yield will not significantly change. He might even have a profit smaller than in conventional cotton because he is paying more for seed costs than before. In this case, adopting GE technology is not beneficial for the farmer.

Suppose there was another farmer, however, this time in an environment with high pest-pressure. He decides to adopt the Bt cotton and is willing to pay the higher rent. At harvest time, he will find a significant increase in his cotton yield because the toxins in the Bt cotton protected it from pests' presence and destruction. He is able to increase his profitability given the same land compared to when he was using conventional cotton seeds. Seeing the benefits, he begins to use the unproductive land that he has to plant cotton as well in order to expand his production and increase his profitability further.

This model shows the benefit (as measured by reduced costs or increased yield, hence higher profit per acre) GE crops may provide farmers given different levels of pest pressures. At lower pest pressures, benefits in adopting GE crops are negligible or even zero but as pest pressure increases, the benefit of adopting it also increases.

Risk dispersion and Adoption

Risk dispersion talks about how farmers as users of GMOs are able to manage the risks they face. GE crops can be treated as a new technology that is introduced to the farmers. This subsection shows theoretical discussions on how the adoption of GE crops, risk and uncertainty affect one another. Looking at the agriculture sector as a financial market, will a farmer be able to manage his risks when using GMOs? What are the factors that affect a farmer's decision to adopt a GE crop?

Marra et al (2003) reviewed the different and various contributions of available literature that provided a discourse on the economics of risk, uncertainty and learning in the adoption of new agricultural technologies. The literature that deals with uncertainty has considered two paths: 1) technology adoption from the standpoint of investment in a durable asset with an uncertain future value and 2) the relationship between the riskiness of the technology and the utility of a risk-averse decision maker. In relation to GE crops, the latter is more relatable. In one of the papers they cite, a game-theoretic approach was used to understand farmer's adoption of the new technology (Marra et al, 2003). Applying it to GE crops, a farmer tends to take the option value of waiting to adopt GE crops based on the opportunity to observe earlier GE adopters' experience with this new technology. Thus it would be that farmers who observe failure in early adopters will discourage other farmers from adopting, hence, no adoption occurs. Conversely, if they observe success and increased profitability from early adopters, then most or even all farmers will adopt.

Feder et. al (1985) made a deeper analysis of farmers in developing countries using a general conceptual framework that explains the adoption and diffusion processes of new technologies. The framework assumes that the decisions of the farmer are derived from the maximization of expected utility subject to land availability, credit and labor, and other constraints. The decision-making can be described using a model based on extent and intensity of the use of new technology at each point in the adoption process or using a model with equations of motions describing the patterns of parameters affecting his decisions such as information gathering, learning-by-boing, and accumulating resources. Generally, a farmer maximizes his expected utility or profit with respect to land availability, credit and other constraints. His profit depends on his choices of crops and technology in each period. Given the new technology, the farmer faces subjective uncertainty, objective uncertainty or a combination of both. The subjective uncertainty happens because he is not sure how or what combination of inputs to use and how much yield he should expect at every stage of adoption. On the other hand, objective uncertainty arises from the movements in the market on the prices of the inputs and outputs he uses which is beyond his control as a small farmer (Feder et. al, 1985). For the sake of this paper, the new technology refers to the GE crops. It creates the same uncertainties for the farmers. The objective risks are brought about by the unpredictable variations in the yield and prices of inputs (fertilizers, seeds, labor, etc.) and outputs in the market. The subjective uncertainty is present because the farmer does not yet know how to use the GE crop at its best and how much inputs to apply on it.

Similarly, one discussion in Marra et al (2003) is about the role of information and learning on technology adoption. They deem it necessary to treat adoption as a process involving the acquisition of the right information and learning (Marra et al, 2003).This implies that the decision making involved in the adoption process is inter-temporal; there is an earlier period where the farmer learns and discovers information about the GE crop and then a latter period where he finally decides to adopt or not depending on the information he has gathered. The farmer's decision could be revolving around certain factors such as, the difficulty of using the GE crop, the risk he is able to accept the costs he has to face, the quality of information he has gathered and how convincing it was in his opinion (Marra et. al, 2003). Therefore, reducing the subjective uncertainty is crucial in a farmer's decision to adopt.

Moreover, Hiebert (1974) concludes that risk aversion is associated with less use of land and fertilizer in producing the modern crop (Feder et. al, 1985). GE crop adoption could be viewed the same. If it is deemed as a risky choice, then farmers who are risk averse would tend to allocate less land for it and use less inputs on it because of the subjective and objective uncertainty. However, as mentioned earlier, if the stock of information on its use increases then the likelihood of adoption would be higher. The stock of information could be increased by information from other farmers who have used it, learning-by-doing, and extension efforts. Moreover, Hiebert (1974) also emphasizes that likelihood of adoption depends on the physical environment as well. He says that farmers in better physical environments (better soil and water availability) increases the expected utility of income from adoption and so adoption of the new technology is more likely. Feder (1980) comes up with a similar conclusion, that risk aversion affects a farmer's land allocation decisions (Feder et al, 1985).

Another paper of interest is from Just and Zilberman (1983). Their approach provides a theoretical basis for studying the role played by firm size, risk attitudes and the joint distribution of returns, credit constraints and fixed costs of adoption in the choice between two risky technologies. Uncertainty arises from the fact that the farmer is less familiar with the new technology and so he perceives its use as "risky". The same concept could be applied to GE crops, farmers do not understand how it fully works and so considers it risky, even though it is no longer vulnerable to pest or herbicide damage. One of the theoretical results of their model is illustrated in the following example: if pesticide is risk reducing and fertilizer is risk increasing, then one would expect more intense adoption of pesticide technologies by larger farmers, while fertilizer would be more intensely used by smaller farmers who adopt the GE crops. It shows that if an input is risk increasing, it would be more intensely used by small farmers and vice versa. The larger farmers are diversifying their risk by balancing the risk of using the new technology (GE crop) and choosing a low risk input (pesticide). Another important result is that when yields of the modern and traditional technology are highly correlated, the farmers are inclined to lean more heavily toward the tried and proven traditional technology which entails lower risk as land size increases. The high correlation, therefore, acts as a barrier to adoption (Just and Zilberman, 1983).

According to several authors, farmers also might choose to adopt the new technology based on their land size and that farmers with land sizes that are below the critical level might choose not to adopt because of the existence of a fixed transaction cost and information acquisition costs at a given point in time. These results do not hold in the absence of uncertainty because even with a small land but higher yields are ensured farmers will adopt (Feder et. al, 1985).

From all of the discussions above, it could be said that the use of GE crops could help a farmer manage his risks. Farmers will be able to spread their risk while adopting GE crops by combining the use of inputs that have low and high-risk. If a farmer considers GE crops as risky, then he has an option to use a risk-reducing input to complement the GE crop or vice versa. However, what might be problematic is when the GE crop is highly correlated with the traditional crop. Basically, if both are exposed to the same shocks, both will experience the same losses and the advantage of using the GE crop will be lost even if he has diversified his risks. It is also important to note that GE adoption is inter-temporal which was seen in the game theory and learning discussions. A farmer does not decide right away to adopt the crop because of the uncertainty and the risk that he might face. He knows how to wait until he observes others succeed or fail and gathers enough information about the GE technology. It is also a possibility that some farmers adopt because of the advantage they have with their surroundings or that their land sizes are large enough.

B. Empirical Studies

This section looks at the empirical studies that evaluate the impacts of transgenic crops on farmer productivity, biodiversity and health. The impacts of GE crops cannot be generalized because each type is adopted in varying contexts. Most of the studies that have been done on GE crops are on stress tolerance trait because it is more widely used than nutritional improvements and enhanced shelf-life.

The table in the appendix summarizes the journals that studied the effects of GE crops on farmer income and productivity, environment and health, by crop and author. It also includes the empirical studies mentioned in the case study on the Philippines found in section 4.

1. *Farmer Productivity and Profits*

On a meta-analysis conducted by Klümper and Qaim (2014), it showed that GE crops on average have significantly increased crop yields by 21 per cent due to the more effective pest control and lower crop damage. It also has reduced pesticide quantity by 37 per cent and pesticide cost by 39 per cent. However, total production cost is unaffected because the lower cost on pesticides is offset by the higher cost of GE seeds. The profit for adopting farmers are significantly higher by 69 per cent. They also went further and disaggregated the results to see how the results differ between Ht and Bt (with insect-resistant trait). The main difference is that the Bt has significantly larger profits than Ht because of the lower pesticide quantity and costs in Bt. This makes sense because the two as explained earlier have different qualities. Their study also corrects for heterogeneity and other biases and still ends up with a similar result.

In India, the top producer and user of Bt Cotton, results show that there is a comparative advantage in using Bt Cotton over the conventional cotton for small farmers. Results show that insecticide use and cotton crop losses per hectare were lower when using the Bt cotton than the conventional one (Qaim, 2009). It has a higher seed cost but it reduces insecticide use, increases yield and profit per hectare significantly.

Insecticide use has not been completely eliminated because not all the pest insects are targeted by the toxin introduced in Bt cotton but it was effectively reduced (Qaim, 2009). Thus, the target pest populations decreased overtime which created a positive externality on conventional cotton growers, allowing them to reduce insecticide use as well. The larger yield per hectare from the adoption of Bt Cotton provided employment opportunities for agricultural laborers and boosted the rural transport and trading business. The higher income gains also increased the food and non-food demand for the farming households. For every one dollar of direct benefit, there is a corresponding 83 cents of additional indirect benefits to the local economy (Qaim, 2010).

For users of Bt corn, yield per hectare has also been effectively increased. For example, in South Africa, the yield has increased a lot because they face high pest pressures. In China, there has been a large reduction on insecticide use but small effects on yield for Bt rice. In India, there also was a significant impact on insecticide use and yields for Bt eggplant. Even with small yield impacts but large reductions in input costs, farmers gain from the use of GE crops (Qaim, 2009). For the Philippines, net farm, household and off-farm income have significantly improved and the likelihood of falling below the poverty threshold declines with Bt corn use (Yorobe & Smale, 2012). Using a bivariate probit model, Mutuc et al (2012) showed a similar result – that Bt corn has a statistically significant positive effect on yield per hectare because this variety increases pest damage abatement. Moreover, farmers have reduced their likelihood of using pesticides against the corn borer (Mutuc et. al, 2012). So their farm costs would be reduced due to Bt corn adoption.

Generally, it is expected that farmers would experience lower expenditures on herbicides because of the increased tolerance of the crop to the presence of other organisms (i.e. weed) and to reduce the costs of productions through lower expenditures for labor, machinery and fuel as well. However, In Argentina, the opposite was observed, farmers of herbicide tolerant (Ht) Soybeans were buying more herbicide to substitute for tillage. In terms of yield per hectare, there was no significant difference between HT and conventional crops and this is expected because Ht crops prevents losses from spraying herbicide more than increasing yield. Aside from this, the farmers are also paying for a technology fee to use the seeds to the private developers and it is almost equivalent to the saved costs which makes the gross margin effects very small or even negative. In terms of opportunity costs, farmers save more time in working in the farm and so they would have higher non-farm income. Overall, they posted a net benefit to the use of HT varieties for average farm-level profits (Qaim, 2009).

On the contrary, a research conducted by Benbrook in 1999 with 8200 university trials found that GE roundup ready soybeans yield 7-10% less than similar conventional varieties. It was also striking that famers use herbicide 5-10 times more than conventional ones (Azadi and Ho, 2010). This implies that a farmer's profit per hectare would be lower.

Overall, the results show that for Bt and Ht crops farmer have significantly benefitted. The results of these journals show only the benefit of using the crop in terms of profits or costs but it does not show how the production process (e.g. planting, putting fertilizers, spraying insectide or herbicide) and the inputs themselves have an impact on the health of farmers and the environment in their proximity.

2. *Environment*

Agriculture relies on biodiversity for it flourish but if the existence of GE crops destroys biodiversity because of the immunity or gene-transfer, it might make agriculture fail in the long run. Is it really true that GMOs do not harm the environment?

Barrows, Sexton and Zilberman (2014) admits that using agricultural biotechnology poses environmental risks, however, empirical evidence shows that GM crops delivers environmental benefits by maintaining agricultural biodiversity. According to a study conducted by Navasero, et.al (2016), they concluded that Bt eggplant had no significant adverse effects on non-target anthropods (NTA) in the Philippines. It means that Bt eggplant can efficiently and safely protect the crop from insects without harming biodiversity and effectively reduces the farmer's dependence on conventional pesticides. Qaim (2009) was also able to conclude the same about Bt crops; the insects did not build any resistance or immunity towards the toxin introduced to the Bt crop and so biodiversity is maintained.

For Resende et al (2016), they studied Bt maize in seven counties of Minas Gerais in Brazil. In most of the cornfields they surveyed, it showed that insect richness estimated for conventional and Bt cornfields was not significantly different or was lower than on Bt maize. They think that it is because conventional cornfields underwent insecticide spraying. They conclude that insect richness remains dependent on geographical location and a farmer's crop management – like spraying chemical insecticides may exert an influence on it.

Generally, users of Ht crop varieties reduced the use of herbicides that are more toxic to the environment, these are substituted by the use of the less toxic broad-spectrum herbicides. As they switch to less-toxic herbicides and do less tillage, like in the case of Argentina, it helps reduce soil erosion, fuel use and greenhouse gases (Qaim, 2009). A life cycle analysis of the use of Ht sugar beet also shows the lowest ecotoxicity and soil acidity compared to conventional regimes in UK and Germany. This is dependent on the number of herbicide spray applications and the nature of the herbicides applied (Bennett et al, 2004)

Yaqoob et. al (2016) summarized the results of 76 journals that did risk-assessments of approved GE crops. The review concludes that there are no significant harmful impacts of GE crops to any case study to non-target organisms (NTOs) like beneficial insects, soil dwellers, aquatic and land vertebrates, mammals and humans. To conclude, whether Bt or Ht crops were used, there was no significant adverse effect on the environment and on biodiversity.

However, a study conducted in the Philippines show that GE corn has contaminated the white corn variety in Mindanao. From observations in the market place, the white corn has specks of yellow or purple on the cob. They collected and tested samples from the market. The samples tested positive for the some GE varieties of corn. White corn that was generally for consumption and has no terminator gene might no longer be available if the contamination worsens. It endangers the availability of the traditional strain of white corn and the livelihood of white corn farmers. How the contamination occurred or the extent of contamination was unknown. They also mention that a similar situation is happening in Mexico; their white and purple corn were being contaminated with GM genes. It shows that GM crops cannot be controlled in open field settings and risks cross-pollination with other crops as well (Ocampo and Cotter, 2013).

3. Health

Pesticide use is expected to be reduced for the Bt crops. With this in mind, it would improve farmer health conditions because they are less exposed to harmful toxins and chemicals. In China and India, pesticide poisonings were reduced for Bt cotton adopters compared to non-adopters and there was lower pesticide residues in water and food (Qaim, 2009 and VIB, 2013). On the other hand, in India, farmer caloric intake of more nutritious foods has improved because they could purchase higher quality food from the increased profits (Qaim and Kouser, 2013). It shows that food security was improved and dietary quality as well. Also, Bt corn contains less toxins that were probable causes of cancer and other diseases in humans (Qaim, 2009).

Ht crop users are expected to use herbicides more intensively because the crop is protected from damage and so Ht crop farmers are more exposed to chemicals which are deemed harmful for their health. Unfortunately, scientific research is not yet widely available for Ht crops and its effect on farmer health when inhaled or touched.

The next research conducted by scientists used rats, mice or other species to test whether the transgenic crops had possible adverse impacts on bodily functions after ingestion. Domingo and Bordonaba (2011) compiled all the scientific-testing conducted on Bt Maize, Bt Rice and Ht Soybeans. For Bt Rice and Ht Soybeans, generally the results show that those did not have any negative impact on health outcomes for mice, rats and chickens. For Bt Maize, it was observed that some rats had adverse effects on metabolism and organs such as the heart, adrenal glands, spleen and hematopoietic system after conducting a 90-day trial feeding. It could not be concluded if it was a safe product for consumption. However, a later study concludes that GE crops had no proven significant impact on health and that they are as healthy as their counterparts (Yang and Chen, 2015).

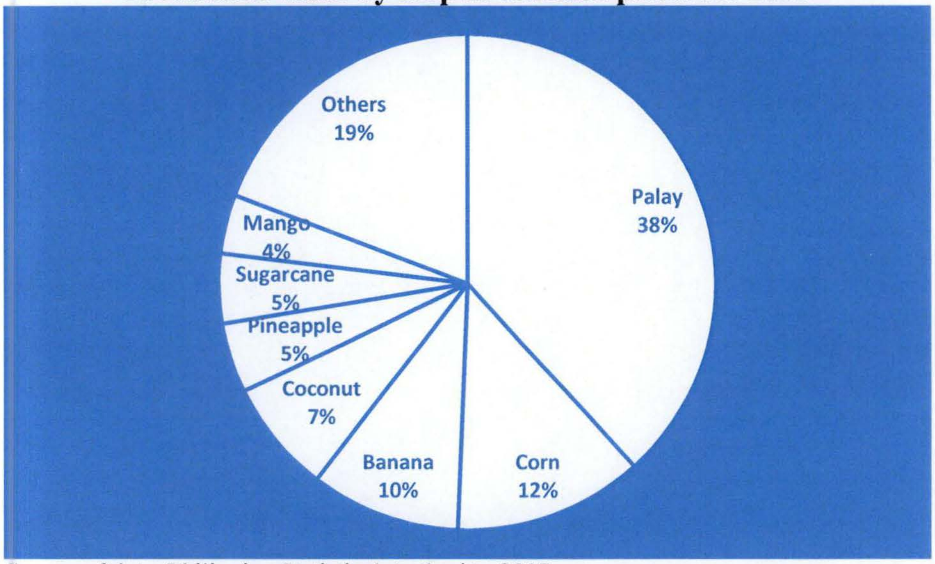
Most of the literature in the 2000s evaluating the environmental and health impacts of GE crops are conducted by affiliates, associates and researchers from the companies producing GE crops as well. Generally, results show that GE crops are as healthy and nutritious as the traditional counterparts. Most of the testing were conducted on Maize soybeans and rice, with rice having the least abundance (Domingo and Bordonaba, 2011). By 2016, more and more literature have been available assessing the impacts of transgenic crops on health and are coming from the biotech companies or independent scientists and research groups. The results remain that transgenic crops are as safe as the non-GMO counterparts. However, it is necessary to conduct long-term impact assessments to fully understand the changes in health alternative to the subchronic (90-day) studies (Domingo, 2016). It is also imperative to conduct assessments on GE crops' potential for allergenicity, microbiological safety and nutritional quality because these issues have not been traditionally assessed widely (WHO, 2005).

III. Case Study: Adoption of Bt Corn and issues in the Philippines

A. Corn Industry

The corn industry in the Philippines is the 2nd largest out of the 68 agricultural crops they produce. As seen on figure 3.1, it was able to contribute 12 per cent of total production in metric tons in 2016. Meanwhile, rice leads the production with a 38 per cent share, followed by corn, then, banana with 10 per cent share, then coconuts with 7 per cent share, pineapple and sugarcane with 5 per cent and finally, mango with a 4 per cent share. Others is the aggregation of the rest of the crops that contribute 3 per cent or less to the total production value.

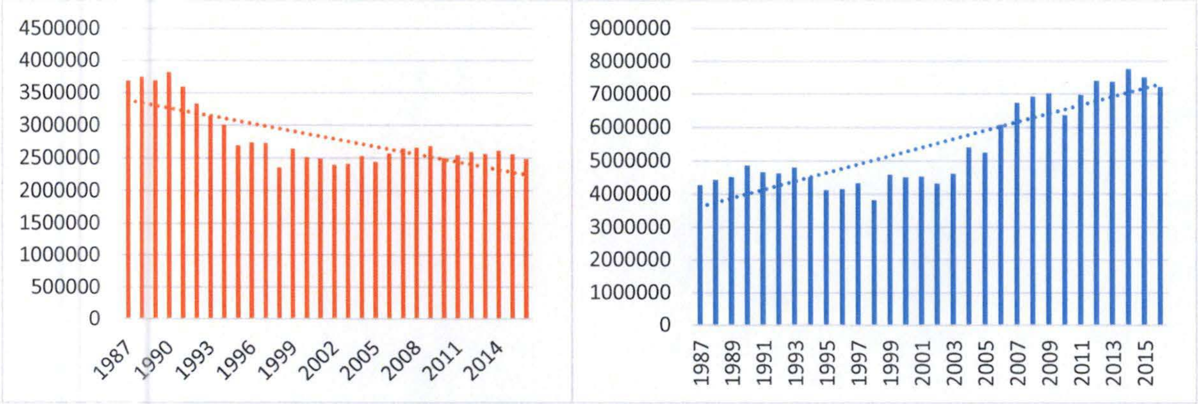
Figure 3.1
Production value by crop in constant prices for 2016



Source of data: Philippine Statistical Authority, 2017

In terms of land coverage, corn is being planted on fewer hectares of land than before. The trend on figure 3.2 illustrates this decline in corn land hectarage. However, it is interesting that although it is planted on less land, its volume of production is on an increasing trend since 1987. It implies that land productivity on corn has been improving since then. It could be attributed to the new agricultural technologies and techniques available.

Figure 3.2
Corn Area Harvested in Hectares (left) and Volume of Production in Metric Tons (right) 1987-2016



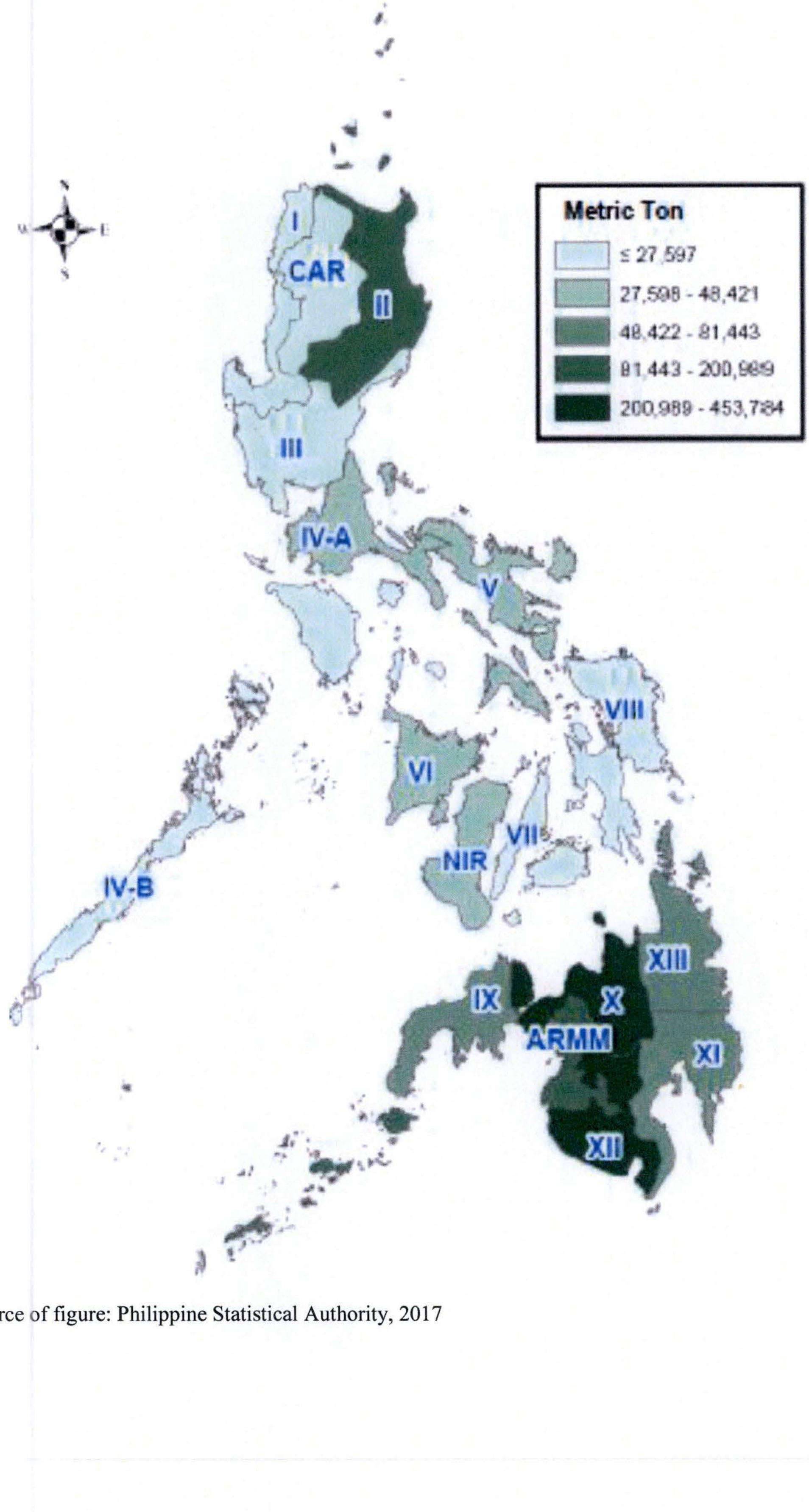
Source of data: Philippine Statistical Authority, 2017

Based on figure 3.3, Region II, X, XII and parts of IX are the top producers of corn in the country because their productivity levels are higher than the rest. Region II is Cagayan Valley, Region IX is Zamboanga Peninsula, Region X is Northern Mindanao and Region XII is SOCCKSARGEN. As seen on table 3.1, the volume of production in Northern Mindanao is highest among the top producers, it produced 453,784 metric tons of corn in 2016. Second is SOCCKSARGEN with 401,707 metric tons of corn produced, Cagayan Valley with 200,989 and Zamboanga Peninsula with the lowest which is 81,443 because only portions of their regions produce corn. Interestingly, both Cagayan Valley and SOCCKSARGEN experienced declines in corn volume production from the period 2015 to 2016. Cagayan Valley faced lower yields because of the negative impact of the typhoon in that region while SOCCKSARGEN was infested by rats and other pests in 2016.

In terms of harvest area, SOCCKSARGEN has the highest with 130,930 hectares followed by Northern Mindanao with 116,768, Cagayan Valley with 52,511 and Zamboanga Peninsula with 47,907. Both Zamboanga Peninsula and Northern Mindanao saw expansion in the corn harvest area from 2015 to 2016, however, on Cagayan Valley and SOCCKSARGEN a contraction is observed. In Cagayan valley, the reduction is because some hectares of land were left fallow and the others were converted to plant cassava. In SOCCKSARGEN, it was because of late planting that left them to harvest in the first quarter of 2017 and so it was not counted for 2016.

The region with the largest yield per hectare is Northern Mindanao and it has grown from the 2015 value by 8.70 per cent. They can produce 3.89 metric tons of corn per hectare. Cagayan valley ranks second with 3.83, unfortunately, this is lower than 2015 because of the typhoon and land conversion that happened in 2016. SOCCKSARGEN does not fall too far behind for they produce 3.07 metric tons per hectare and the reduction in productivity is because of the problems they faced in 2016. Zamboanga Peninsula is the least productive of all, it only produces 1.70 metric tons of corn per hectare, and however, this is seen as a slight improvement from 2015.

Figure 3.3
Corn Production By Region, 2016



Source of figure: Philippine Statistical Authority, 2017

Table 3.1
Volume of Production, Harvest Area and Yield per hectare in the Top Corn Producing Regions, 2016

	Vol of Production (in thousand metric tons)	Harvest Area for Corn (in hectares)	Yield for Corn (in metric tons per hectare)
Region II: Cagayan Valley	200,989 *(-12.84%)*	52,511 *(-11.12%)*	3.83 *(-1.94%)*
Region IX: Zamboanga Peninsula	81,443 *(7.29%)*	47,907 *(5.28%)*	1.70 *(1.90%)*
Region X: Northern Mindanao	453,784 *(13.00%)*	116,768 *(3.96%)*	3.89 *(8.70%)*
Region XII: SOCCKSARGEN	401,707 *(-5.40%)*	130,930 *(-2.49%)*	3.07 *(-2.99%)*

*The year-on-year change with 2015 is inside the parenthesis
Source: Philippine Statistical Authority, 2017

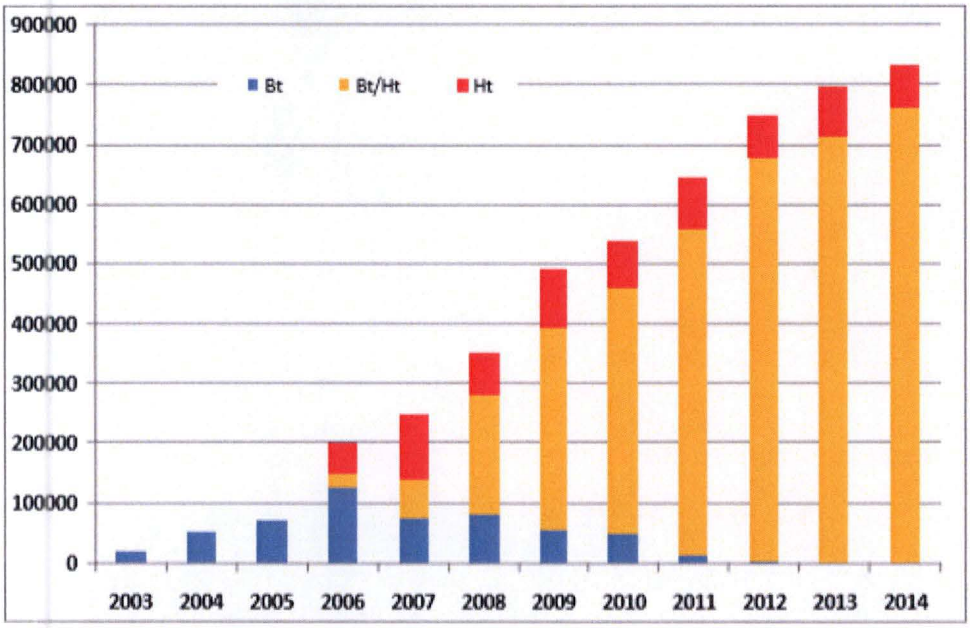
B. GMOs in the Philippines

Bt corn was first introduced in the Philippines in 1996 for limited field trials. In 2002, they are the first to approve the commercial distribution of it through the Department of Agriculture (Mutuc et. al, 2012). Other than that, they are also the first to adopt Bt Corn for food and feed production and are pioneers of agri-biotechnology research and development in the ASEAN region. With the help and oversight of the government, they are developing several biotech crops in public institutions, such as rice, papaya, banana, sugarcane, potato and tomato (Teng, 2008). An example is the Philippine regulatory system which was established in 1992 to set the adoption of biotech corn in the Philippines with further amendments and supporting memoranda in 1999, 2002 and 2006 (Aldemita, et al, 2014).

Furthermore, they have been hailed as the first country in Asia to have commercialized GMOs. As of 2014, there are 13 varieties of GM corn approved for planting and about 820,000 ha of agricultural land is devoted to GM corn (Aldemita, et al, 2014). The GM corn widely used are the herbicide tolerant and insect resistant varieties which are being planted by about one-third of Filipino farmers (Mutuc, et al, 2012). Being pioneers in biotech research, the country is recognized as having one of the strictest biosafety regulations (Masipag, 2016).

In figure 3.4, the GM corn hectarage has dramatically increased in just about over a decade. In 2003, there was only about 20,000 ha of GM corn and in 2014, it rose up to 820,000 ha. The adoption during those years was very fast because of the support and promotion of the Department of Agriculture, since its approval in 2002. Moreover, it is interesting to point out that the use of the plain Bt strain has zeroed out since 2013 since more farmers are using the stacked traits of Bt/Ht corn or the pure Ht strain. The stacked traits include both insect resistance and herbicide tolerant. It reflects the farmers' preference for the stacked traits due to its superior benefits over the single traits (Aldemita, et al, 2014).

Figure 3.4
Hectarage of Bt Corn in proportion of commercialized traits in the Philippines (2003-2014)



Source: Compiled by ISAAA, 2014 (Aldemita, et al, 2014)

As of 2015, the share of Ht hectarage to the total corn harvest area is computed as 3.36 per cent while the stacked trait Bt/Ht is computed as 23.50 per cent. As a whole, the GE crops have about 26.86 per cent share of the total land harvest area devoted to corn (Biotechnology Philippines, 2017). The two major corn producing provinces in the Philippines are Isabela and Cotabato. In the same provinces, adoption of hybrid varieties especially the Bt corn were high (Yorobe & Smale, 2012). These farmers adopted Bt corn mainly due to the infestation of the Asian corn borer with pest pressure increasing yearly. Farmers aim to reduce the yield losses as they suffer about thirty to almost one hundred percent (Mutuc et. al, 2012).

1. Contradicting claims on Bt Corn by proponents and opponents

Opponents of Bt corn use in the Philippines use mostly qualitative data to make their claims against it and should be interpreted with caution. The results in the research conducted by MASIPAG (2013) and Green Peace (2005) were derived from surveys in different areas of the Philippines.

MASIPAG (2013) shows an adverse impact on Filipino farmer net income for biotech corn in the twelve areas surveyed from different parts of the Philippines. They conclude that smallholder farmers experience increasing indebtedness because of traders/financiers, loss of ownership of their lands and control over their seeds, food insecurity from loss of biodiversity including heavy soil erosion and threats to physical health. The traders or financiers provide the seeds and inputs to the farmer to be able to plant the GE corn. Even in good or bad harvests, the farmers remain indebted to the financier because of their monopsony relationship. Being the sole buyer for the farmer he financed, the trader/financier can dictate the price of yellow corn; usually lower than market prices (Masipag, 2013). Aldemita et. al (2014) mentions the same issue as well, that 8.1% of Bt Maize farmers have to deal with local traders that dictate low buying prices. Moreover, MASIPAG claims that these financiers charge farmers an interest higher than banks for the loans the latter takes on inputs and seeds. In desperation, some farmers try to cut costs by saving some GE corn seeds to plant for the next season but it produced poor results (Masipag, 2013).

In cases of bad harvests, farmers will not be able to repay the trader/financier for the seeds and inputs and so he will be forced to give up his land as payment. The small farmers, having very few assets, can only put up their land as a collateral when taking credit or a loan. The farmer ends up as a worker on his own land just to make ends meet after losing his land to the trader. With GE corn, farmers lose control over their lands because of the power of the trader. The trader, apparently, can also force the farmer to use GE corn and specific inputs, otherwise, he will not lend to them. The traders, upon selling more and more of the GE corn seeds and specific inputs, receive incentives from the companies producing them (Masipag, 2013). The traders exploiting the small-holder farmers reinforces the negative view on GE crops (Sharma, 2004). On the contrary, a study by Larson (1988) says that upon closer examination of traders in Cagayan de Oro and General Santos, the traders are not as bad as we thought them to be. They perform the essential marketing services of transferring the products from production areas to consumption areas in the right amount, time and form.

Overtime, the GE corn farmers observed changes in their environment where soil erosion has increased and became infertile, super pests and super weeds have emerged, biodiversity is lost, and a new plant disease has developed (Masipag, 2013). Soil health is compromised because of the toxins present in Bt corn that accumulate in the soil (Greenpeace, 2005). This is verified by the farmers interviewed by Masipag (2013), they complained that the soil requires increasing amounts of fertilizers in order to achieve good harvest. Also, the corn borer has become resistant to the Bt Corn and a corn plant hopper (CPH) has emerged, hence, both the Bt corn and stacked variety of corn have become vulnerable and infested again. The Roundup herbicide has been unable to exterminate a weed called *oyampong*. They also complain that planting fruit trees, vegetables or root crops close to their farmlands do not thrive because of the effects of the herbicides. A new disease called Banded Leaf and Sheath Blight (BLSB) has been reported in 2011 in North Cotabato and their corn farms are infected by this soil-borne fungus. The disease was traced to the no-till farming due to the incessant use of Roundup herbicide. A similar story is found in Isabela where the farmers see that the Asian corn borer has grown resistant to the Bt toxin (Masipag, 2013 and Greenpeace, 2005).

Corn farmers have also become more food insecure because of the loss of wild vegetables and not being able to grow vegetables and root crops close to GE corn farms. They have become more dependent on market purchases which is contrary to the idea that using GE crops would improve food security. The farmers and their families who eat the GE corn also experience the acute effects of agrochemicals such as shortness of breath, dizziness, numb lips or tongue, diarrhea etc. Amidst the farmers' observed disadvantages of planting GE corn, they seem to have been left without a choice given their situation (Masipag, 2013).

Greenpeace (2005) shares the same sentiments as Masipag. They argue against the use of Bt Corn in the Philippines saying that GE crops are unpredictable and might create long lasting damage. They also believe that it breeds greater dependence on chemical inputs for the reason that Bt corn has to be complemented with the use of a larger number of chemical inputs. Bt corn uses 15 bags of fertilizers for a hectare while the alternative seeds use fewer bags: open-pollinated varieties use 2-3 bags and hybrids use 6 bags. Hence, in terms of profitability, farmers are worse-off using Bt corn with a higher seed and chemical input costs per hectare (Greenpeace, 2005).

On the contrary, empirical studies shows a different outcome after Bt Corn adoption. Aldemita, et al (2014) enumerates benefits received by Filipino farmers from using biotech corn in different peer-reviewed journals. First, farms planted with biotech corn have significantly higher populations of beneficial insects – i.e. flower bugs, beetles, and spiders - than conventional hybrid corn in the northern areas. Second, the net national impact on farm income was estimated at US$ 92 Million for 2013. Third, farmers of biotech corn are able to gain additional profits and are able to save due to lower insecticide costs. Specifically, farmer profits per hectare is about US$ 180 and savings per hectare is US$ 3. Fourth, planting biotech corn during the wet season gives 4-7% advantage and on the dry season 3-9% advantage than the conventional corn. The additional income per hectare each farmer receives during the dry and wet season are US$ 135 and US$ 125, respectively. Overall, the Philippines already has gained USD 470 million from using biotech corn since its approval in 2002.

A second study by Mutuc et al (2012) estimates the impact of Bt corn adoption using cross-sectional data from 470 farmers, 107 of which are Bt corn users and 363 are non-Bt users for the period 2003-2004. The farmers on average had a land size of 2.04 hectares, where the Bt adopters had 2.39 hectares and non-bt adopters had 1.92 hectares. The results suggest that Bt corn adoption provides a modest but statistically significant increase in farm yields and profits. Moreover, it also provides a negative effect on the likelihood of pesticide use and pesticide demand is significantly reduced. It also had a statistically significant fertilizer reducing effect. The results reflect the initial impact of Bt corn during the first few years of its availability and when overall adoption was still low for these small-scale farmers.

Yorobe and Smale (2012) estimated the same impact using primary data collected from Isabela and South Cotabato for the small-holder farmers between the periods 2007 and 2008. The results showed that net income per hectare was larger by PhP 4,300.05 for Bt Corn users because of the lower yield losses. Location was also significant which implies that Isabela farmers were earning more than their counterparts in South Cotabato. Using the Kernel density to predict net farm income, it showed that Bt users have a higher distribution compared to non-Bt users implying that using Bt maize could help alleviate poverty in communities. Off-farm income was also improved significantly because of the amount of labor freed under Bt maize farming allowing farmers to take other off-farm income-generating activities like driving, carpentry, work, buying and selling merchandise, office employment and others. Household income, the total of off-farm and on-farm income, was also significantly higher for Bt corn users than non-Bt corn users by PhP 7,964.31.

These contradicting results from different journals just reflect the worldwide debate on GMO use in the local context of the Philippines. The opponents argue negative impacts on net farmer income, loss of land and biodiversity loss while the proponents show that net farmer income has been positively affected. However, it is interesting to point out that the qualitative studies and the quantitative studies are not on the same level. The stories and sentiments shared by Masipag and Greenpeace still has to be empirically tested for it to hold ground in the scientific world. No tests on causality has been conducted to determine if these negative outcomes were brought about by the adoption of Bt corn or not. Those might have happened possibly even without the use of Bt corn given the local context. Thus, one cannot fully attribute those negative outcomes to the use of Bt corn unless scientifically tested. So far, more research still has to be done on the role of the financier and traders in the Bt corn market. Are they really exploiting the small farmers or are they just charging higher rates because of the risk that they are absorbing? Also, the impacts of Bt corn on biodiversity and the ecosystem should also be studied. The Philippines has been using it for almost 15 years and so there could be enough data and samples in order to conduct an impact assessment on it in the top corn producing regions. This is to prove whether the claims of the opponents really are true.

2. Farmer experiences on Bt Maize in Bukidnon Province

In this province, corn is mostly planted in upland, marginal lands because the plateaus are mostly planted with rice. It is also possible for the farmers to plant on plateaus if it is not suitable for rice farming – i.e. there is no irrigation source available. The farmers that were interviewed mostly had 2 hectares of land or less indicating that most of the information in this section would mostly be about small farmers. Those that have 5 hectares of land or more are very few in number and often have political positions, such as *Barangay* Chairman or *Purok* Chairman.

In a preliminary interview conducted in three barangays – Bendum, St. Peter and Silae, it was found that Bt Maize was not desired by small farmers mainly due to greater indebtedness, loss of land, and low corn yields or even, crop failure. Thus, their adoption rate is very low which implies that a lot have given up its use and there are a number of the farmers that still use these. These farmers used to plant GE corns such as Round-up ready corn, yellow corn with glyphosate, and bio-seed healer which were introduced to them by the financiers, fellow farmers or company representatives of the seed. In the 1990s, hybrid corn was introduced in Bendum by a financier. In Silae, no specific period was mentioned but the yellow corn was introduced by a financier as well. In 2003, yellow corn with glyphosate by Monsanto was introduced in St. Peter.

As mentioned above, farmers were hesitant or even stopped using Bt Maize for reasons that will be explained hereon. Farmers who adopted these newly introduced GE corn were promised a larger yield per hectare, hence, a larger profit per hectare. In St. Peter, the yield was advertised to be 6,000 kilos per cropping per hectare but he only receives up to a maximum of 5,000 kilos. Farmers from Silae, who also use the GE yellow corn, report that they can get as much as 5,000 kilos. It seems as if that the yield generated by field trials are not being met in these areas. This illustrates that it only works on certain land conditions or environments. Moreover, farmers that were attracted to this promise of a larger yield became more willing to pay for the seed rent and the additional chemical inputs they would need. They would be disappointed as harvest comes because yield is not as they expected it to be. In

St. Peter, a farmer going through financing mentions that he always makes less than break-even and always has to work extra or sell off their pig just to pay off the deficit. However, it is possible that he and all other farmers do not earn greater due to lower corn prices and not just because of low yields.

Basically, farmers experience greater indebtedness when they experience crop failure. According to the interviews, farmers can get access to this more expensive crop through financing. They get credit from a financier in their locality with a 10% interest rate per month in St. Peter and Bendum and 8% per month in Silae for the duration of the cropping season which lasts about 4 months. Some financiers are in a monopoly position and others have a few but they communicate among each other and potentially collude. It is also possible to borrow from the government banks with an interest rate of 3% per month until the debt is repaid. With government banks, farmers are quite discouraged from borrowing because of the process they have to go through – i.e. filing papers, providing a collateral and waiting for approval. Most of them choose to go to the financier more than the government banks because the interest rate stops after 4 months although it is much larger in comparison. So those who are interested in making more profits per hectare with the Bt maize went through financing.

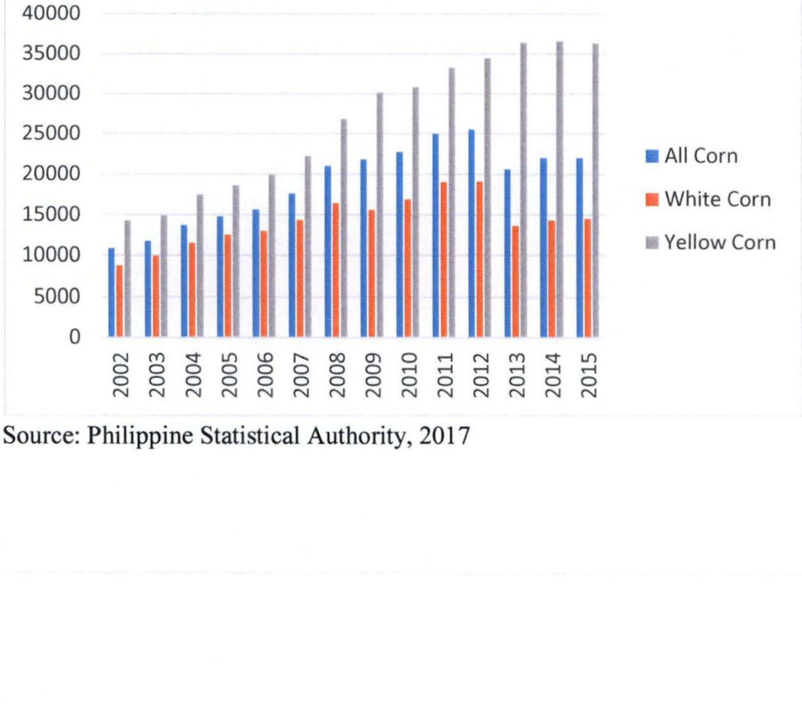
With the uncertainty of seasons in the Philippines, farmers are exposed to risk when going through financing. There are two scenarios that can happen: if they borrow from a financier and experience a good harvest, then they would not have a problem repaying their debt and still retain profit. On the contrary, if they borrow from a financier and experience a bad harvest due to bad weather or pest outbreak, then they would not be able to repay. It leaves them in debt, without profit and means to get by. In the latter scenario, the financier can choose to do the following: not lend or wait until the farmer repays the debt, *prenda* - use the farmer's land that was financed and make the farmer work until debts are repaid, or *embargo* - completely take ownership of the land. In the experiences of farmers in Bendum and St. Peter, there have been instances where the financier took the land of the farmer who was unable to pay his debt. In St. Peter and Silae, some farmers were allowed by the financier to borrow again just to ensure that he will get repaid by the farmers. There were times the financier just waited until he gets repaid. These circumstances and risks discourage the farmers from Bendum and St. Peter to continue using the Bt Maize. However, in spite of the risks, it is surprising that farmers from Silae continue to use it even if they have experienced crop failures while going through financing.

The traders in these *barangays* also provide marketing services to these corn farmers. Some of the other services they provide are transportation, bags, bagging, shelling, drying, grading, storage and milling as well (Larson, 1988). Of course, these services come at a cost to be paid by the farmer or be deducted from the sales revenue they will receive.

To follow up on the issues raised by the farmers themselves in Bukidnon, economists and the organizations that are opponents of GE crops, some data will be presented on corn production costs, yield per hectare and farm gate prices on a national level. Figure 3.5 illustrates the increasing production costs for all corn. It is interesting to observe that yellow corn is more expensive to produce than white corn and that the gap between the two is widening. It suggests that either the price of the inputs (whether the labor, fertilizers, pesticides, etc.) used in yellow corn are increasing or that they are using increasing amounts of inputs for the same hectare of land, *ceteris paribus*.

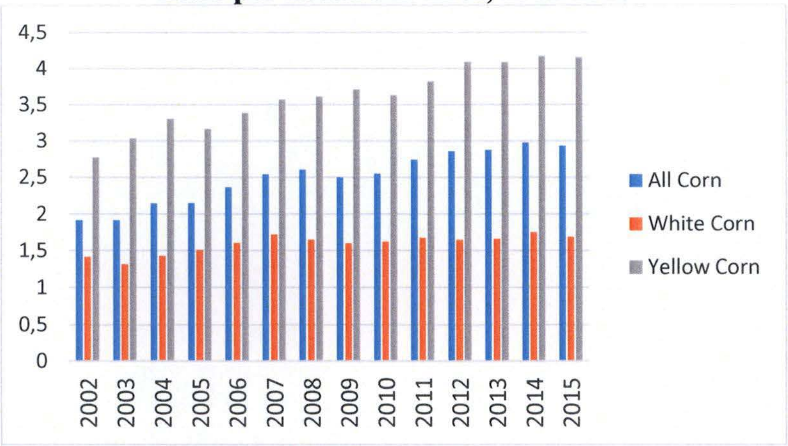
Yellow corn is producing more yield than white corn consistently over time. The differential between the two is also increasing over time as seen on figure 3.6. Most of the yellow corn are the GE ones, and so with more protection from pests, they are able to produce more in one hectare than white corn. The higher production costs in yellow corn might be compensated by the large yield in produces. The trends showed in figure 3.7 show an increasing trend for yellow and white corn farm gate prices from 1990 to 2015. Surprisingly, white corn has a price higher than the yellow corn. Is the higher yield per hectare of yellow corn enough to offset the benefits of higher prices with the white corn? As learned in basic economic courses, prices are determined by the market forces. It could be that yellow corn is in much more demand than white corn and so the price of yellow corn is much lower. It is also possible for the white corn to be scarcer than yellow corn implying a higher price for it.

Figure 3.5
Total Corn Production Costs Averaged for the Wet and Dry Seasons, 2002-2015



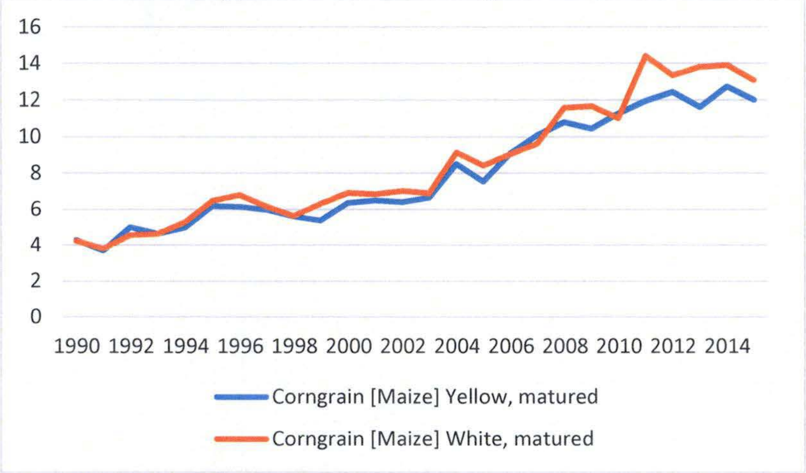
Source: Philippine Statistical Authority, 2017

Figure 3.6
Yield per hectare in kilos, 2002-2015



Source: Philippine Statistical Authority, 2017

Figure 3.7
Corn Farm gate Prices in Pesos per Kilo, 1990-2015



Source: Philippine Statistical Authority, 2017

IV. Economic Analysis

Certainly, there is no question about the benefits of planting GE crops. They do increase yield per hectare (regardless of land size) because of the increased resistance of the crops to pests and destructive chemical inputs. The main problems of GE crops have to do with economic and environmental issues. The environmental issue is the building of immunity of the pests or emergence of stronger pests that have ensued years after use of Bt/Ht crops. Meanwhile, the economic issue about the use of GE lies central to the political economy structure that it is built upon deteriorates the situation of the small farmer more than the large farmer. Because the purposes of this paper are highly economic and short- to medium-term, the latter issue will be focused on in the following analysis but a short discussion would be done on the how to deal with the environmental issue as well.

The information collected in the previous sections could be summarized into general potential benefits, potential costs and potential risks of adopting Bt or Ht crops for small-scale and large-scale farmers. The small-scale farmers will be defined as having land holdings of 2 hectares or less and large farmers are 2 hectares and more. The smaller land holdings could indicate the larger vulnerability of small-scale farmers versus the large-scale ones and so the behavior and issues faced by the two farmers would be different, except when a similar shock hits the two, such as, extreme weather conditions and pest infestations. Because small-scale farmers have a small portion of land, the costs of spending on mechanical inputs or any other farming machine (e.g. harvesters, trucks) will be too burdensome. The small scale farmers have a constrained capital or even no source of it.

Prior to adopting the GE crop, both the small and large-scale farmers have to learn about the correct way of using it. Not learning fully will result in failing to optimize the conditions to achieve a better harvest with GE crops. Thus, one of the potential costs they might face is the time and effort they spend just to learn about GE crops. Another cost is the higher input costs as they pay for the seed rent and other inputs, such as, fertilizers, pesticides (if still necessary) and herbicides that complement the GE crop. These costs mentioned are found on table 4.1 and for the small-scale and large-scale farmers on using Bt crops, these are the same.

As for the benefits, it would be the same for the two types of farmers as well. The promises of GE, in this case Bt crops, that there would be a higher yield per hectare and since less pesticides are used, the farmer faces less health risks.

The main difference between the two types of farmers adopting GE crops lies on the potential risks they face. Considering to adopt GE crops would mean that these small farmers would have to face higher costs and so they rely on trader/financiers as a source of credit in order to finance their farming for the succeeding cropping season. As mentioned in other journals, the small farmers would try to get credit in informal institutions (i.e. trader, financier) where the transaction costs would be lower, for example, only verbal agreements with few paperwork (Burkett, 1988). The trader to small-farmer relationship has been dubbed "unhealthy" by concerned organizations because of the *prenda* and *embargo* schemes that they do. Moreover, they act as monopsonists for harvest periods and monopolists for planting periods. During planting season, these traders sell the GE crops as a package with the expensive inputs and has the right to decline to sell, if a different input combination is desired. During the harvest season, the traders dictate the prices when buying from the small farmers and with a weak bargaining power, the farmer is left with no choice but to accept. With this risk, the general idea on GE adoption becomes strongly negative as these small farmers are exploited (Sharma, 2004). Large-scale farmers do not face this risk with traders because they have their own source of financing or go through formal institutions to transact. If crop failure happens to them, they carry their own burdens and can find a way to finance the deficit.

Table 4.1
Qualitative Analysis of Adopting Bt Crops

	Bt		
	Potential Costs	Potential Benefits	Potential Risks
Small-scale	1.Seed Rent 2. Fertilizers 3. Pesticides, Herbicide, Labor 4. Learning Technology	1. Less exposure to pesticides that are harmful for the health. 2. Higher yield per hectare	1. Crop Failure due to pest infestation or extreme weather conditions 2. Dependence on the trader 3. In LR, pests possibly become immune to the toxin in Bt
Large-scale	1. Seed rent 2. Fertilizers 3. Pesticides, Herbicide, Labor 4. Learning Technology	1. Less exposure to pesticides that are harmful for the health. 2. Higher yield per hectare	1. Crop Failure due to pest infestation or extreme weather conditions 2. In LR, pests possibly become immune to the toxin in Bt

Finally, the potential risks that are similar for the two are the crop failure that arises due to pest infestation or extreme weather conditions and immunity of the pests to the toxins. These exogenous shocks affect farmers similarly irrespective of their land size or wealth. However, the aftermath of these shocks for the small-scale farmer are worse than large-scale farmers. As already mentioned, the former's ties with the trader puts them in a vulnerable position when crop failure happens. The traders could dominate the small farmer by taking control of his land through *prenda* or *embargo*. In the case of the Philippines, the immunity was an issue that was reported by farmers to Masipag (2013). This issue has to be addressed by the GE crop developers, otherwise, the costs of pesticides would rise back up again or crop losses would get worse. This in turn might discourage current and possible future users of the GE crop just to reduce the risks that they face. The immunity built by pests could be circumvented if the Bt is enhanced frequently. Another way is that the farmers should be advised not to do mono-cropping each time. They should be taught to let the land rest so that the targeted pests can be exposed to other plants and not be able to build immunity. This would be easy on plateaus but for upland farming, it would be challenging to find other cash crops suitable for that kind of plant.

V. Conclusion

The GMO crop industry has been immensely expanding since its inception in 1983. A lot of crops are now modified to withstand extreme climates and pests, to be more nutritious, to contain new chemicals to be used for industry or pharmaceuticals, and to last longer in shelves. The most commonly used GE crops are corn, cotton and soybeans. There is a wide on-going debate about GMOs: proponents support its use due to economic reasons and opponents deny support due to uncertain effects on health and environment, monopolization of the industry, and negative impact on small-scale farmers.

To verify the claims in the debate, published empirical journals were surveyed and it has been proven that the use of Bt crops significantly increases a farmer's yield per hectare with decreases in pesticide use, thus increasing profitability, generally. On the other hand, Ht crops leave the yield per hectare the same, thus, profit per hectare could be the same or even lower, if a farmer uses far more herbicide than before. It is observed that there is a lack of empirical research on the impact of adoption on the farmer's health himself and the environment in proximity when using the chemical inputs for the GE crop. As for the environment and health concerns, scientific research on 90-day trials show that GE crops are as healthy as their counterparts and have no negative impact on the environment. However, it shows that there aren't any studies conducted on its long term impacts on health (inhalation, skin contact or ingestion), environment and even profit, especially for Ht crops.

The Philippines is known world-wide as a large user of GMOs with a strict biosafety regulation. Corn is one of the crops that is mostly produced in the country. Data from 2015 shows that about 26 per cent of the total hectarage for corn is allotted to herbicide-resistant and the stacked trait (Ht mixed with insect resistance) GE crops. There is some literature available that discussed and tested empirically how the use of Bt corn changed socio-economic aspects and environment. In papers that did empirical testing, they ended up with the same conclusion as above, that GE crops are good for farmer profits in general. In papers that did qualitative analysis, they found that small-scale farmers are losing profits, lands, suffering from worse health because of the presence of traders and pests became resistant to the Bt toxins. Specifically in the province of Bukidnon in the Northern Mindanao, farmers have a similar experience with the traders. A number of farmers have stopped using Bt corn because of the consequences of dealing with the trader and that the expected yield is not being met. It shows that even in the Philippines, there are varying opinions about GE crops. However, it is important to mention that the two different analyses do not bear the same weight. The qualitative analyses should still be verified using empirical testing and further research.

For future research in the Philippines, it would be interesting to conduct an in-depth study of financiers and traders to verify if they really are exploitative or just simply absorbing a larger risk with these small farmers. Given also the large possibility of crop failures due to the volatile weather patterns in the country, the government should put into place policies that lower the impact of crop failures on farmers who have contracts with these financiers in order to reduce the farmer's likelihood of indebtedness and loss of land and also to provide assurance to the financiers as well.

In this simple analysis, it can be concluded that GE crops are not that bad taking it at farmer level. Income per hectare is improved but small farmers face a much larger problem than large scale farmers when crop failure happens. They are tied to the trader/financier whereas the large scale farmer is not. If there was a way to reduce or even remove the power of the trader both as a monopsonist and monopolist, then would it change the minds of the opponents of GMOs in the Philippines and everywhere else? Would it make adoption faster? If it does, it would leave the long run impact on environment and health as the only unquantified risk of using GMO crops.

APPENDIX

Table: Summary Table of some Empirical Studies on GMOs

	Farmer Productivity and Profits	Environment	Health
Bt Cotton	Yield and profit per hectare increased due to lower insecticide use in India (Qaim, 2009).		Fewer pesticide poisonings for farmers from China and India (Qaim, 2009 and VIB, 2013)
			Farmers are able to intake more and better quality nutritious food because of the increased profits (Qaim and Kouser, 2013)
Bt Corn	Yield per hectare has been increased in South Africa (Qaim, 2009)	Bt cornfields had more insect richness than conventional cornfields because farmers spray less insecticide (Resende et al, 2016).	It contains less toxins that were probable causes of cancer and other diseases in humans (Qaim, 2009)
	Net income per hectare was larger than conventional farmers because of lower yield losses in Philippines (Yorobe and Smale, 2012)		
	Gain additional profits and are able to save due to lower insecticide costs in the Philippines(Aldemita et al, 2014)	Contaminated the traditional strains of corn – white corn in the Philippines and purple and white corn in Mexico. There is a risk of cross-pollination (Ocampo and Cotter, 2013)	Some rats had adverse effects on metabolism and organs after a 90-day feeding trial (Domingo and Bordonaba, 2011).
	Significant increase in farm yields and profits with a lower pesticide and fertilizer use in the Philippines (Mutuc et al, 2012)		
Bt Rice	Incremental increase on yield per hectare but a large reduction on insecticide use in China (Qaim, 2009).		
Bt Eggplant	Large reduction on insecticide costs and small increase in yield per hectare in India (Qaim, 2009).	No significant adverse effects on non-target anthropods in the Philippines (Navasero et al, 2016)	

Ht Soybeans	Very small or even negative impact on income per hectare because yield was not significantly changed and farmers are paying for a higher seed cost in Argentina (Qaim, 2009)	Farmers substitute less-toxic herbicides when using Ht soybeans for the more-toxic ones in Argentina (Qaim, 2009)	
	Yields 7-10% less and farmers use 5-10 times more herbicide than conventional crops (Benbrook, 1999)		
Ht Sugarbeet		Lowest ecotoxicity and soil acidity compared to conventional regimes in the UK and Germany (Bennett et al, 2004)	
General	GM crops have increased crop yields by 21%, reduced pesticide use by 37% and pesticide cost by 39%, thus, the profit per hectare is higher by 69 per cent (Klümper and Qaim, 2014)	Whether Bt or Ht crops, there is no significant adverse effect on environment and biodiversity (Yaqoob et al, 2016)	No proven significant impact on health as they are as healthy as their counterparts (Yang and Chen, 2015)

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