# Biotechnologies in the Philippines: The Cost of Regulation

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ABSTRACT

Biotechnologies potentially have significant benefits for developing countries but many countries lack complete regulatory processes to allow their release. In evaluating the potential benefits of genetically modified crops, one must be able to measure the true cost of regulations in addition to the other costs associated with bringing the crop to market. The objectives of this paper are to (1) identify the direct costs of the regulation of Bt eggplant, Bt rice, ringspot virus resistant (PRSV) papaya and virus resistant tomatoes in the Philippines, and (2) estimate the opportunity cost of time lost in the regulatory process. The study compares the cost of regulations as they differ by factors such as the existence of previous studies on the product or the intention for export or domestic use. It is hypothesized that the costs are greater for products that are intended for export or human consumption or are produced by the private sector. It is also hypothesized that these factors increase the time to complete the regulatory process, therefore increasing the opportunity cost of time.

This study evaluates the economic impact of the GMO regulatory process on the change in producer surplus, the net present value and the internal rate return using an economic surplus model. Scientists and other experts in the field of GMOs and regulation were interviewed to obtain the necessary data on the regulatory process. The evaluation was carried out for four different commodities in the Philippines, Bt Rice, Bt Eggplant, PRSV Papaya and MVR Tomato. The results for the open economy model revealed a change in producer surplus, as a result of the GMO research, of $418.3 million for Bt Rice and $353.7 million for PRSV Papaya. The closed economy model of Bt Eggplant has a change in producer surplus of $25.1 million and a change in total surplus of $40.8 million while the result for the change in producer surplus for MVR Tomato is $19.3 million and the change in total surplus is $51.6 million. A sensitivity analysis of the results was then carried out in which the elasticity of supply, the cost of regulation, and the release date were each varied in order to show the welfare impact of such changes. The sensitivity analysis revealed limited changes in surplus when elasticity and regulatory costs were changed. However, changing the date of release or commercialization resulted in monumental changes in surplus.

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# TABLE OF CONTENTS

## List of Tables

## List of Figures



## List of Acronyms

NCBP – National Committee on Biosafety of the Philippines
BPI – Bureau of Plant Industry
GMO – Genetically Modified Organism
AO – Administrative Order
EO – Executive Order
IRRI – International Rice Research Institute
IPB – Institute of Plant Breeding
PhilRice – Philippine Rice Research Institute
UPLB – University of Philippines, Los Banos
BAS – Bureau of Agriculture
P – Filipino Pesos
IBC – Institutional Biosafety Committee
STRP – Scientific and Technical Review Panel
IFPRI - International Food Policy Research Institute
NBF – National Biosafety Framework
$1 (one dollar US) = P50 (50 Filipino Pesos)
NPV – Net Present Value

# Biotechnologies in the Philippines: The Cost of Regulation

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## Chapter I. Introduction

Biotechnologies potentially have significant benefits for developing countries, but many countries lack complete regulatory processes to allow their release. A suitable regulatory process is necessary for the safety of those who consume genetically modified organisms (GMOs) as well as for the environment that might be indirectly affected by their products. Countries throughout the world have been bombarded by the views of both GMO opponents and proponents on the regulations that should or should not be imposed. Each nation needs a fair set of regulations that are both protective and efficient. In setting these regulations, countries must be cautious, not overly restrictive unless they intend to delay or even forgo the benefits of the technology.

### I A. Research Problem

In evaluating the potential benefits of genetically modified crops, one must be able to measure the true cost of regulations in addition to the other costs associated with bringing the crop to market. A cost benefit analysis that does not include regulatory costs loses its usefulness. In addition to varying by country, regulatory costs vary depending on many mitigating factors specific to each respective organism. For example, the costs differ based on whether or not similar products have been brought to market and their respective bio-safety tests may be applied to the new products, if the biotech product has previously been tested in other countries, whether or not the product is to be exported, and whether the product has been initiated by the public or private sector. Each increase in the time required to bring a product to market subsequently increases the benefits forgone. Economic evaluation requires an accounting of the regulatory costs and the opportunity costs of time lost. Policy makers need to know what the costs of regulations are so as to make informed decisions on the efficient application of existing or proposed regulations.

The benefits of genetically modified organisms have been estimated for various crops, but there is a lack of detailed information with respect to cost analysis. A need exists for an estimation of the costs of genetically modified organisms, specifically with respect to their research and regulatory costs as well as opportunity costs from time delays.

## I B. Objectives

The objectives of this paper are to (1) identify the direct costs of the regulation of Bt eggplant, Bt rice, ringspot virus resistant (PRSV) papaya and virus resistant tomatoes in the Philippines, and (2) estimate the opportunity cost of time lost in the regulatory process.

The paper will compare the cost of regulations as they differ by various factors mentioned above. For example, as the costs differ across sectors, intended final consumption use, and the existence of similar products that have completed the regulatory process, the cost of regulations will be compared.

**I C. Hypotheses**

It is expected that the cost to the public sector will be less than the cost to the private sector to adhere to the same regulations. It is also expected that the products intended for human consumption as opposed to animal consumption will have a more extensive regulatory process than previous products such as *Bt* maize or *Bt* cotton. This increased regulatory scrutiny will likely increase the time it takes to bring the product to market, thereby increasing the total cost of the regulatory process. The costs are likely to increase when the product is intended for export. For each of the above factors, the increased time lag they imply for the regulatory process will imply an opportunity cost of bringing the product to market. This regulatory cost analysis will provide an estimate of direct regulatory costs of genetically modified plants as well as the opportunity cost of delaying commercialization of the plants.

In order to define the current regulatory process in each of the specific countries, existing documented regulations were reviewed and government officials, researchers and other experts in the regulatory process were interviewed. The interviews were used to assess in what circumstances bio-safety and other tests from other countries are accepted and how that acceptance changes the cost of testing the product within the country. They were used to estimate the costs of each regulatory step and how the cost differs by different type of product, specifically with respect to products meant for human consumption as opposed to products for animal feed. These interviews focused on estimating the cost and time of completion of each of the following steps in the regulatory process:

- Project Proposal
- IBC Risk assessment

- Development of genetic lines, quality evaluation (NCBP)
- Limited Field Trial, confined/isolated field (NCBP & DA AO8)
    - Gene flow tests
    - Food safety assessment
    - Toxicity Tests
    - Efficacy tests
    - Environmental safety tests
- Multi-location field trial (DA AO8)
    - Gene flow tests
    - Food safety assessment
    - Toxicity tests
    - Efficacy tests
    - Environmental safety tests

Following the interview process, economic surplus and benefit cost analyses were conducted to estimate the opportunity cost of varying time lags due to the regulatory process, drawing on recent studies by Francisco, Yorobe, and Mamaril (2005, 2006). Recently, cost benefit analyses have been completed for each of the GMO products previously mentioned. Assumptions have been made about the time it will take to release a product and the costs incurred. However, as the timing of release to market changes, so does the cost and benefits. Using data and models from the studies of each of the specific products, the change in surplus were calculated and then discounted using the net present value method to produce the opportunity cost of delaying the release of each plant. The interest rates used were the social rate of interest as opposed to the market rate of interest.

The literature currently available includes discussions of the economic impact of the technology when it is released to market including the recipients of the benefits, the effect on farm income, and the impact on pesticide use, return on investment and the effects of intellectual property rights. Regulatory costs, including the opportunity costs of time, are rarely included in the literature on genetically modified organisms.

Information was drawn from the studies by Francisco, Hareau, Mamaril, and Pray, amongst others.

The following chapters begin with a discussion of the approach of this paper and the empirical methods. This discussion includes the interview process, differentiation between development costs and regulatory costs and the economic surplus model. The next chapter discusses the data, followed by a chapter discussing the results. Finally, there is a chapter for conclusions drawn from the paper and limitations of the research.

## I D. Organization of Thesis

Analyzing economic surplus changes due to GMO regulatory costs first requires a distinction between regulatory costs and product development costs. There will innately be some overlap within these costs where a process or test is both required within the regulatory process and necessary to develop the product. Because of this overlap, there is much debate over which tests and processes should be distinguished as regulatory costs. There is additional controversy about tests that are done preemptively; that is, tests that are done in anticipation of possible regulatory requests by the NCBP or the BPI.

For the purposes of this paper, tests and processes that are concurrently required for development and regulation are included as regulatory costs. However, tests completed in anticipation of possible regulatory requests are not be included; the reason being that there is no guarantee that each of these preemptive actions are used within the regulatory process, nor would there be any consistency among various products. Finally, each test explicitly stated in the Republic of the Philippines Executive Order (EO) 514, EO 430, and Administrative Order (AO) 08 is included as regulatory costs.

The regulatory process was identified through a series of interviews in addition to reviewing the Philippine executive and administrative orders. These interviews were conducted in various cities within the Philippines including Los Banos, Manila and the research facility PhilRice in Munoz, Nueva Ejcia. Scientists and experts from the Institute of Plant Breeding at UPLB, IRRI and PhilRice were selected for interview because of their expertise within the field and on the given commodities targeted in this paper. For an alternative perspective, regulators from the Department of Science and Technology and from the NCBP were interviewed. Their expertise is primarily in the field of policy and regulation creation, and membership on the NCBP board (either current or previous). Their views balance the information from scientists and help to prevent bias in the interview data gathered.

From the above described research and interviews, the cost of the following list of regulations was estimated:

1. Establish the Institutional Biosafety Committee (IBC)
2. Submit Project Proposal to IBC which is then submitted to the National Committee on Biosafety of the Philippines (NCBP)
    a. IBC Risk assessment using Rational Risk-Benefit Analysis before submission to NCBP
3. NCBP creates Scientific and Technical Review Panel (STRP) concurrent with public notification by the IBC
    a. STRP evaluates potential adverse affects to humans and the environment
4. Application to Bureau of Plant Industry (BPI) for Contained Testing and Importation of regulated articles

    a. Conditional on endorsement by the NCBP

5. Risk Assessment by the BPI
6. Application to BPI for Field Testing (only after contained testing has been completed)
7. Field Testing (either single field or multiple location, but each field evaluated separately)
    a. Conditional on receipt of field test permit
    b. Conditional on successful contained testing
8. Permit for Release for Propagation or Commercialization
    a. Conditional on field testing results
    b. Conditional on food and feed tests

Essentially, each progressive step of the regulatory process allows for increased exposure to people and the environment given a successful passing of the risk assessment during the previous regulatory step. The detailed regulatory process is published on the Department of Science and Technology's NCBP website, http://www.ncbp.dost.gov.ph/. The source of information on the above regulations is the publications by the NCBP as well as the interview of scientists and professionals in the field of GMOs in the Philippines. The NCBP is primarily responsible for regulating the development and release of GMOs until the point on the process during which they would have contact with the environment, at which point the responsibility shifts to the Bureau of Plant Industry.

# Chapter II. The Model

In addition to identifying the regulatory process, interviews were used to find the timeline and cost of each regulatory step. Since the process has not yet been completed for any of the target commodities, the costs and time to completion have been estimated for those steps that occur at the end of the process. These estimations are based on past experience of the experts interviewed with other commodities, as well as projections based on the growth cycles of each plant.

## II A. Economic Surplus Model

The timeline and cost of each regulatory step identified in the interviews is used to measure the aggregate impact of research delays and their distribution among producers and consumers. This measurement was achieved using an economic surplus model drawn from the work of Alston, Norton, and Pardey (1995). The model was varied based on the assumptions utilized in the literature discussed later in this paper. The models were then narrowed down to a small open economy model as used by Yorobe in his PRSV Papaya study and Mamaril and Norton in their economic evaluation of rice biotechnology impacts in the Philippines, and Vietnam and a partial equilibrium closed economy model as used by Mamaril in his study of MVR tomato and Francisco in his study of *Bt* eggplant.

### A1. Closed Economy Model

The closed economy model, as described algebraically below, assumes a parallel shift of the supply curve where both the supply and demand curves are assumed to be linear. Since this paper is using a partial equilibrium model as opposed to a general equilibrium model, it is also assumed that other commodity prices are constant. Algebraically, the formulas for consumer surplus, producer surplus and total surplus in the closed economy model are expressed as:

Consumer surplus: $\mathbf{\Delta CS = P_t Q_t Z(1+0.5Z\eta)}$

Producer Surplus: $\mathbf{\Delta PS = P_t Q_t (K-Z)(1+0.5\,Z\eta)}$

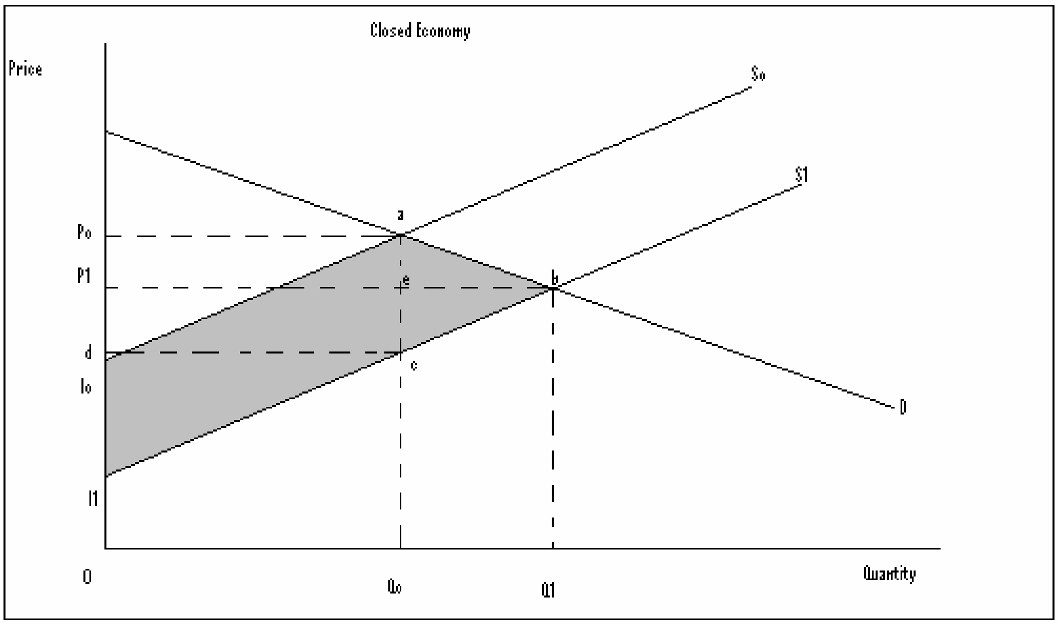
Total Surplus: $\mathbf{\Delta TS = \Delta CS + \Delta PS = P_t Q_t K(1+0.5Z\eta)}$

Price Change: $\mathbf{Z = K\varepsilon/(\varepsilon+\eta) = -(P_{(t+1)} - P_t)/P_t}$

where $P_t$ and $Q_t$ are the price and quantities respectively at time t. K is the vertical shift of the supply curve, either up or down. Z is the change in price due to the supply shift. The absolute value of the price elasticity of demand is expressed by η, and the elasticity of supply is expressed by ε. (Figure 2.1)

Graphically, the closed economy model is shown in figure 2.1. In this model, D represents demand, $S_0$ and $S_1$ represent supply before and after the research induced shift. $P_0$ and $Q_0$ are the initial equilibrium price and quantity, after the shift price and quantity are represented by $P_1$ and $Q_1$. Total surplus after the shift is equal to the shaded area, $I_0abI_1$. Change in consumer surplus is the area $P_0abP_1$ and change in producer surplus is equal to the area $P_1bI_1$ less the area $P_0aI_0$.

Figure 2.1 Closed Economy Economic Surplus Model



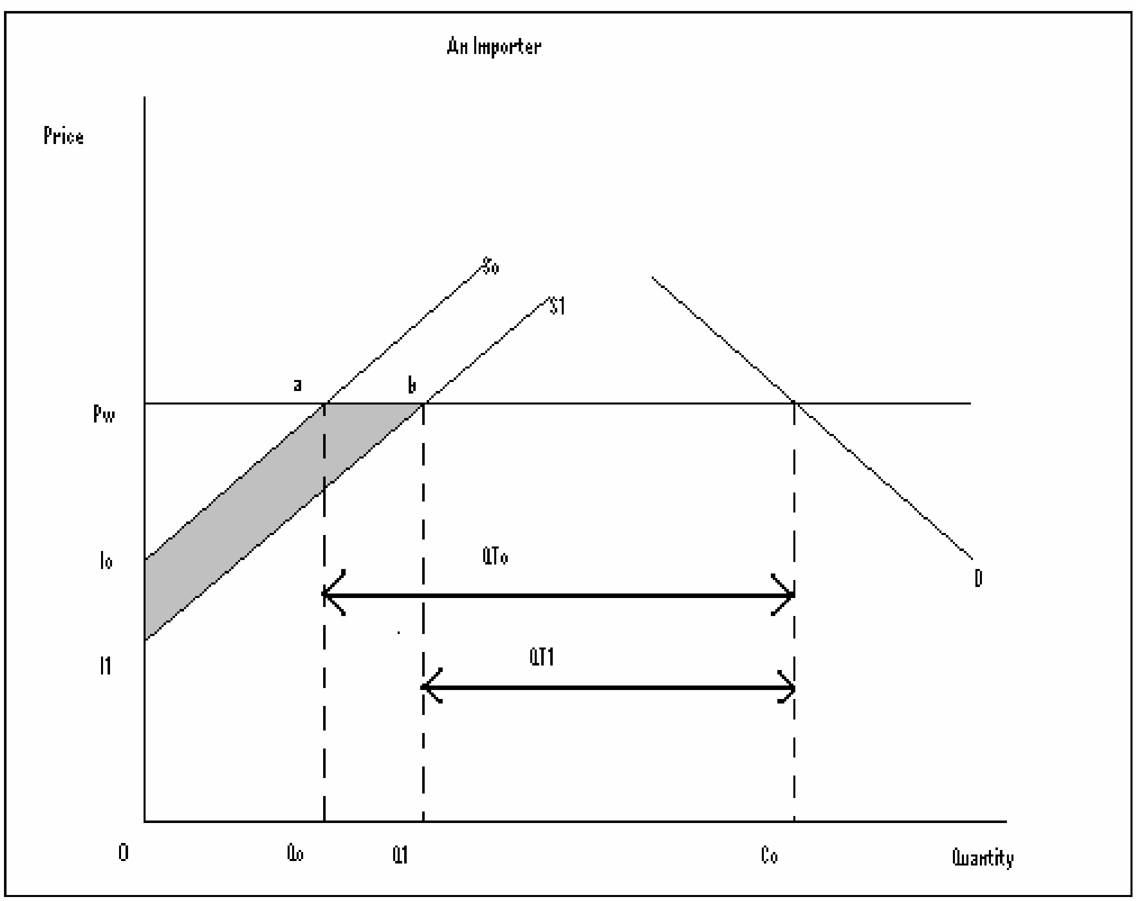

**A2. Small Open Economy Model**

In the case of the small open economy, as used in the studies of PRSV Papaya and *Bt* Rice, the assumption of a parallel shift in the supply curve is maintained. It is assumed that the subject country of trade, in this case the Philippines, does not affect the international price of the commodity, the world price, $P_w$ is a constant, and all benefits are reflected by an increase in producer surplus after the shift in the supply curve. The change in producer surplus can then be denoted as:

Producer Surplus: $\mathbf{\Delta PS = \Delta TS = P_w Q_0 K(1+0.5K\varepsilon)}$

where K is the parallel shift of the supply curve, either upwards or downwards. This formula applies for both a small country exporter and a small country importer. Figure 2.2 graphically depicts the open economy model for a net importer. In this figure, $P_w$ depicts the world price, D is demand, $S_0$ is the original supply and $S_1$ is supply after the research induced shift. The initial equilibrium consumption level is the point $C_0$ and the equilibrium production is $Q_0$ with a traded quantity of $QT_0$. Research increases production to $Q_1$, resulting in a change in trade to $QT_1$. Since the small country, in this case, the Philippines, doesn't affect the world price, all of the economic surplus goes to producers. The change in producer surplus is then depicted by the shaded area $I_0abI_1$.

Figure 2.2 Small Open Economy Economic Surplus Model



# Chapter III. Data and Model Parameterization

## III A. Data and Data Sources

The data and other information used in this study are from primary and secondary sources. The primary data were gathered by interviewing government officials, scientists and other experts in the regulatory process, and reviewing the existing documented regulatory process as stated in EO 430, EO 514, and AO 08. The sources of the secondary data were the studies by Francisco, Yorobe, Mamaril and Norton, and data sets made available by the Bureau of Agricultural Statistics (BAS). The secondary data consists of background information on each of the commodities and the base parameters of the economic surplus models. This includes the price of each commodity in US dollars, the quantity in metric tons, the rates of adoption and depreciation of adoption, probability of research success, the cost of research, the change in input costs and the expected yield change. Also included in all four studies is the elasticity of supply and in the two closed economy models, the elasticity of demand. Each of the papers referencing a specific commodity pertinent to this study uses the Alston, Norton and Pardey (1995) method for their economic surplus models. In cases where US dollars needed to be substituted for Philippine Pesos, the exchange rate was assumed to be \$1=50PhP.

The Bureau of Agricultural Statistics (BAS) is the main government organization within the Philippines that collects and disseminates agricultural statistics. The BAS was the source of data describing the relevance of each of the applicable commodities in the previous section. The BAS publications used as the source of this data were the commodity fact sheets for 2003 and 2004, the agricultural performance sheet for the first half of 2006 and The Selected Statistics on Agriculture for 2006.

According to the Philippine Bureau of Agriculture (BAS) commodity fact sheet for 2004, the Philippines is a net exporter of papaya. The Philippines total domestic consumption of papaya was 122,719 metric tons with a value of $26.73 million in 2003. The total value of Papaya exports was 3,324.02 metric tons with a value of $4.69 million. The domestic consumption of rice was 9,586,000 metric tons with a value of $4095.14 million. The Philippines is a net importer of rice and these imports consist primarily of semi-milled and wholly-milled rice, excluding broken rice according to the BAS.

The interview subjects were scientists from research institutes in the Philippines including the Institute of Plant Breeding (IPB) in Los Baños, PhilRice in Maligaya, experts from the University of the Philippines in Los Baños, government officials from the Department of Science and Technology (DOST), and an agricultural economist from the International Food Policy Research Institute (IFPRI). The primary information obtained from these interviews includes clarification of the regulatory steps, timing of completion of each of the steps within the regulatory process and the cost of each step. The interviews also revealed how differences in product type, end-user, intention to export, previous scientific testing, and consistency within the regulatory and scientific community affect the cost of each of the regulatory steps as well as the time to complete the steps. See appendix A for the complete interview questionnaire.

The executive and administrative orders describe the documented regulatory process for the Philippines. Executive Order 430, signed by President Corazon Aquino on October 15, 1990, created the National Committee of Biosafety of the Philippines

(NCBP) under the Department of Science and Technology. The role of the NCBP, as described by the EO 430, is to identify potential hazards, formulate policies and guidelines with respect to GMOs, promote risk assessment research and supervise biotechnology research. EO 514 adopted and put into operation the National Biosafety Framework (NBF) for the Philippines. The objectives of the NBF are to minimize risk by "strengthening the existing science-based determination of biosafety…" (EO 514), make the application process more efficient, and "serve as guidelines for implementing international obligations on biosafety"(EO 514). This order reveals the priorities of the NCBP and the Filipino government with respect to biosafety regulations and further defines the responsibilities of the NCBP within the functions of biosafety policy, accountability, science and capacity building. EO 514 also mandates the responsibilities of the DOST, Department of Agriculture (DOA), the Department of Environment and Natural Resources (DENR), the Department of Health (DOH) and any associated departments and agencies. Finally, this order creates a guideline for the biosafety decision making process with a standard of precaution as was described in the Cartagena Protocol, setting risk assessment as central and mandatory in making sound biosafety decisions, followed by the application of environmental impact assessment and socio-economic, ethical and cultural considerations, also as described in the Cartagena Protocol. Administrative Order number 08 outlines the rules and regulations for the import and release of genetically modified plants and plant products into the environment. Similar to the orders discussed above, the rules created by AO 08 are based on the assessment of risk created by the release of a modified plant product into the environment. This order outlines all rules and regulations from the point of contained testing during which the modified product has no exposure to the environment or general population through to field testing at which point the risk of exposure is significantly increased. The summation of all of these rules and regulations can be found in the NCBP's publication of the Philippine Biosafety Guidelines (PBG). The PBG outlines the composition of the NCBP, the Institutional Biosafety Committee (IBC), and the Biological Safety Officer(s) (BSO) as well as outlining the application procedures, evaluation procedures, and all of the rules and regulations related to GMOs. The PBG applies to products modified or created within the Philippines and those products imported to the Philippines.

## III B. Model Parameterization

Sergio Francisco's economic impact assessment of fruit and shoot borer resistant Eggplant assumes a small closed economy. For his base parameters, a supply elasticity of 0.5, and a demand elasticity of -0.8 are assumed. Francisco arrived at the elasticity of demand based on the work of Orogo (1976) in which the general demand elasticity for fruit bearing vegetables was estimated to be -0.85 and for vegetables in general was estimated to be -0.75. It was therefore assumed that the demand elasticity for eggplant is approximately (-0.8). Francisco arrived at the supply elasticity of eggplant based on the high level of seasonality in the growth of eggplant as well as the production limitations of eggplant when price is high. Farmers can not increase production to match increases in price during the wet season due to the inability of eggplant to grow in overly wet areas. From the BAS, Francisco was able to gather the necessary information on cost, yield, prices and production for the base parameters of the model. He projected a yield increase of 40%, a decrease in input costs by 16%, a price of $200 per metric ton, and a production of 182,750 metric tons. A maximum adoption rate of 50% was assumed since the new seeds do not require much of a change in current farming practices. The probability of success of the technology was 70% based on interviews with scientists and other experts. The technology was assumed to depreciate at a rate of 5% per year beginning in year 5 after its release, with the technology eventually becoming obsolete. (Table 3.1)

The elasticities of demand and supply for MVR Tomato were obtained from the ex-ante evaluation by Cezar Mamaril. That study assumed a small closed economy with an elasticity of demand between -0.3 and -0.6 with a mean value of -0.45, an elasticity of supply between 0.5 and 1.0 was assumed, with a mean of 0.75. The elasticity of demand was based on the studies by Burleigh and Black (1999) and Aure (1982). Mamaril based the elasticity of supply on estimates from other countries since there was no information specific to tomatoes grown in the Philippines. He stated that the value may be lower than that which was used as Filipino farmers who grow tomato are able to easily substitute out of tomato to other crops. A sensitivity analysis that includes this possibility is discussed in the results section. Once the technology is implemented, yield is projected to increase by 67% and input costs are expected to decrease by 10%. It is projected that the technology will have a success rate of 74% and that adoption of the new tomato variety will reach a maximum of 70% after just two years (Table 3.1). This short time frame was due to the short production cycle of tomato and severity of the virus problem. It was also projected that the technology will depreciate by 10% per year three years after the initial release due to resistance breakdown. A price of $215 per metric ton and a quantity of

152,690 metric tons were assumed in the base model. The price was based on 10 years of past quantities produced.

Yorobe assumed that the economy was small and open for his PRSV papaya study. It was therefore unnecessary to estimate the elasticity of demand for the analysis. The supply elasticity was assumed to be 0.8. He based this assumption on the belief that the supply elasticity of Mango is between 0.4 and 0.6. The base model assumed that adoption of the new technology would increase yield by 77% and increase costs by only 8%. The probability of research success was 83% with no technological depreciation and a maximum adoption level of 90% beginning with 30% adoption upon initial release increasing by 10% each year. (Table 3.1).

The source of the base model data for *Bt* Rice is Mamaril and Norton's (2006) economic evaluation of transgenic pest resistant rice. Similar to Yorobe's PRSV Papaya study, a small open economy is assumed. From Mamaril and Norton's evaluation, it was gathered that the elasticity of supply for rice in the Philippines is approximately 0.95. This assumption was based on the work of Minot and Goletti (1997) and Hossain (1998). Their study varied this elasticity in a sensitivity analysis. A similar sensitivity analysis is discussed in the results chapter of this thesis. The parameters of the base model obtained from this study included a price of $180 per metric ton based on the average price paid for Philippine rice imports and a quantity of 10.5 million metric tons. The yield was projected to increase by only 2.4%. The reason for such a small increase in yield is that the rice plant, in the presence of stem borer damage, compensates by producing new tillers. The experts did not anticipate any change in the cost of inputs and expected research success. Adoption was projected to increase by 6% each year after initial release, reaching a maximum of 66% in year 11 (Table 3.1).

**Table 3.1. GMO Adoption and Depreciation Patterns**

| | **Bt Eggplant** | | **MVR Tomato** | | **PRSV Papaya** | **Bt Rice** |
|---|---|---|---|---|---|---|
| year | Adoption | Depreciation | Adoption | Deprectiation | Adoption | Adoption |
| 1 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.00 |
| 2 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.00 |
| 3 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.00 |
| 4 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.06 |
| 5 | 0.01 | 1.00 | 0.00 | 1.00 | 0.30 | 0.12 |
| 6 | 0.05 | 1.00 | 0.00 | 1.00 | 0.40 | 0.18 |
| 7 | 0.12 | 1.00 | 0.23 | 1.00 | 0.50 | 0.24 |
| 8 | 0.25 | 1.00 | 0.47 | 1.00 | 0.60 | 0.30 |
| 9 | 0.40 | 0.95 | 0.70 | 1.00 | 0.70 | 0.36 |
| 10 | 0.50 | 0.90 | 0.70 | 0.90 | 0.80 | 0.42 |
| 11 | 0.50 | 0.85 | 0.70 | 0.80 | 0.90 | 0.48 |
| 12 | 0.50 | 0.80 | 0.70 | 0.70 | 0.90 | 0.54 |
| 13 | 0.50 | 0.75 | 0.70 | 0.60 | 0.90 | 0.60 |
| 14 | 0.50 | 0.70 | 0.70 | 0.50 | 0.90 | 0.66 |
| 15 | 0.50 | 0.65 | 0.70 | 0.40 | 0.90 | 0.66 |

It is believed that there will be no breakdown of resistance by the plant in the near future and therefore the depreciation of the technology is assumed to be zero. The parameters of the base economic surplus model for each of the aforementioned commodities are summarized in Table 3.2.

**Table 3.2. Base Model Parameters for Economic Surplus Analysis**

| | Bt Eggplant | Bt Rice | PRSV Papaya | MRV Tomato |
|---|---|---|---|---|
| Elasticity of Supply | 0.50 | 0.95 | 0.80 | 0.75 |
| Elasticity of Demand | 0.80 | n/a | n/a | 0.45 |
| Expected Change in yield | 40.0% | 2.4% | 77.0% | 67.0% |
| Change in Input Costs per ha | -16.0% | 0.0% | 8.0% | -10.0% |
| Probability of Success | 70.0% | 10000.0% | 83.0% | 74.0% |
| Price (US$/MT) | $200.00 | $180.00 | $363.70 | $215.00 |
| Quantity (MT) | 182,750 | 10,500,000 | 159,000 | 152,690 |

The above parameters were used in conjunction with the primary data gathered during the interviews with experts, scientists and government officials. This data included the regulatory cost for each year of examination and the time period during which all tests were conducted. In each case, the commodity has not yet been released for commercialization, therefore it was necessary for those interviewed to project, based on their experience, the amount of time it would take to reach the point of commercialization and the cost. These projections varied greatly from one commodity to the next due to differing amounts of information available. According to the scientists, the Philippine government has received products already released in other countries or products that were developed by private organizations that decided it was not cost efficient to continue the research. Rather than let it go to waste, they donated it to garner good will with participating governments. Variances in the projected time to complete the regulatory process occur due to the differing stages in which the technologies are received by researchers as well as the various growing cycles of each plant. The cost of regulation was primarily divided into the major research divisions, the lab tests, screen house tests, confined field trials and the multi-location field trials. In some cases, such as *Bt* rice, this was further divided by the tests that were conducted on the commodity. In this instance, the cost of each of these tests were summed to give the complete value for that research division.

From each of the scientists and experts interviewed, a projection of the time duration of the regulatory process was received. A projection of the cost for each year in this time period was also obtained. When available, the research costs and times were also received. The PRSV Papaya research time and costs coincided with those presented by Yorobe in his economic impact report. It was estimated that the research occurred over a period of four years, costing approximately $120,000. The end result was an initial generation of the PRSV Papaya plant, designated $T_0$. The first two generations of the PRSV Papaya plant generated from the $T_0$ line, designated $T_1$ and $T_2$, were then tested in a confined screen house location over a two year period, costing approximately $20,000 per year. They expected that the isolated field trial would begin in year three during which they evaluate the $T_3$ generation at an estimated cost of $45,000. Once this evaluation was completed the $T_3$ generation would be tested again, this time in a multi-location field trial over a two year period, costing approximately $42,000 per year. During the second year of the multi-location field trial, the researchers would produce the $T_3$ seeds for commercialization. At this point, the PRSV papaya seeds would be ready for commercial release which was estimated to occur over a 1 year period at a cost of $30,000. In total, the research and regulatory testing was expected to take 10 years at a total cost of $319,370, consisting of 4 years of research at $120,370 and 6 years of regulatory testing at $199,000. Table 3.3 displays these costs and analysis that vary these costs and time periods are discussed later in the paper.

*Bt* Eggplant and MVR Tomato have similar growing seasons and are being researched in the same facilities. For this reason, they have nearly identical cost and time estimates for their regulatory testing, although the cost of research for each is not the same. *Bt* Eggplant's $T_0$ generation was created over a 7 year period costing $580,000. Confined testing of the $T_1$ generation began during the fifth year of research and consisted of two years of testing, costing $90,000 each year. This testing will be followed by one year of confined field testing costing $100,000, and a year of multi-location field testing costing another $100,000. Commercialization is projected to occur during year nine at a cost of $95,000. MVR Tomato also required 7 years of research costing $62,000 per year expect year two in which the cost was $82,000. Regulatory tests were projected to begin in year 8, with two years of confined screen house testing followed by one year each of confined field trial and multi-location field trial. The cost of the screen house testing was projected to be $90,000 per year while the cost of each year of field testing was expected to be $100,000. Commercialization costs were projected to be approximately $95,000 and would occur during the first year of product release. In each case, the gene technology had been developed outside of the Philippines and donated to the government for development in native Philippine lines of tomato and eggplant.

While PRSV Papaya, MVR Tomato and *Bt* Eggplant are being developed and tested by researchers and scientists at UPLB and IPB, *Bt* Rice is being developed and tested at the Philippine Rice Research Institute (PhilRice) in Nueva Ecija. Research on

Bt Rice occurred over a 3 year period and cost approximately $296,000 per year. This research was followed by five years of regulatory testing. The first year consisted of confined screen house testing, costing $20,800, while the second year comprised the limited field testing which cost $446,700. Years 3 and 4 were reserved for multi-location field testing which was estimated to cost $105,000 per year. The final year includes all commercialization costs which occur concurrently with public release. These costs were projected to be $13,180 (Table 3.3).

**Table 3.3. Regulatory and Research Costs for each GMO**

| | Bt Eggplant | | MVR Tomato | | Bt Rice | | PRSV Papaya | |
|---|---|---|---|---|---|---|---|---|
| Years | Research | Regulatory | Research | Regulatory | Research | Regulatory | Research | Regulatory |
| 1 | 100,000 | - | 62,000 | - | 296,243 | 0 | 41,667 | 0 |
| 2 | 100,000 | - | 82,000 | - | 296,243 | 0 | 23,148 | 0 |
| 3 | 100,000 | - | 62,000 | - | 296,243 | 0 | 23,148 | 0 |
| 4 | 100,000 | - | 62,000 | - | 0 | 20,800 | 32,407 | 0 |
| 5 | 80,000 | 90,000 | 62,000 | - | 0 | 446,700 | 0 | 20,000 |
| 6 | 60,000 | 90,000 | 62,000 | - | 0 | 105,000 | 0 | 20,000 |
| 7 | 40,000 | 100,000 | 62,000 | - | 0 | 105,000 | 0 | 45,000 |
| 8 | - | 100,000 | - | 90,000 | 0 | 13,180 | 0 | 42,000 |
| 9 | - | 95,000 | - | 90,000 | | | 0 | 42,000 |
| 10 | | | - | 100,000 | | | 0 | 30,000 |
| 11 | | | - | 100,000 | | | | |
| 12 | | | - | 95,000 | | | | |

The assumed induced delay in date of release while regulatory procedures are being followed is indicated in table 3.4

**Table 3.4. Revised Adoption and Depreciation Timelines for each GMO**

| | Bt Eggplant | | MVR Tomato | | Bt Rice | PRSV Papaya |
|---|---|---|---|---|---|---|
| Year | Adoption | Deprecation | Adoption | Depreciation | Adoption | Adoption |
| 1 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.00 |
| 2 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.00 |
| 3 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.00 |
| 4 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.00 |
| 5 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.00 |
| 6 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.00 |
| 7 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.00 |
| 8 | 0.00 | 1.00 | 0.00 | 1.00 | 0.06 | 0.00 |
| 9 | 0.01 | 1.00 | 0.00 | 1.00 | 0.12 | 0.00 |
| 10 | 0.05 | 1.00 | 0.00 | 1.00 | 0.18 | 0.30 |
| 11 | 0.12 | 1.00 | 0.00 | 1.00 | 0.24 | 0.40 |
| 12 | 0.25 | 1.00 | 0.23 | 1.00 | 0.30 | 0.50 |
| 13 | 0.40 | 0.95 | 0.47 | 1.00 | 0.36 | 0.60 |
| 14 | 0.50 | 0.90 | 0.70 | 1.00 | 0.42 | 0.70 |
| 15 | 0.50 | 0.85 | 0.70 | 0.90 | 0.48 | 0.80 |

## III C. Model Sensitivity Analysis

This section describes the various sensitivity analyses run with the economic surplus model based on the data discussed above. It begins by describing the sensitivity analysis that varies the elasticity of supply for each of the four commodities. This analysis is followed by a discussion of the effects of varying the cost of regulation. There is a report being released shortly that also addresses the regulatory costs of PRSV Papaya Yorobe and Laude (2007). The cost sensitivity analysis here considers the differences in costs assumed by this paper and those by Yorobe and Laude (2007). Finally an analysis of various time delays and gains is discussed. The length of delays and gains is based on the scientists' and experts' views on how they might be able to streamline the regulatory process so as to shorten the time to commercialization and where time lags may occur due to delays within or redundancies in the regulatory process.

As discussed in the data section, the values assumed for the elasticity of supply, ε, and the elasticity of demand, η, were based on the assumptions used in the respective studies of Yorobe, Mamaril and Francisco. Each of these values was based on the values of similar commodities due to the lack of availability of a known elasticities for specific commodities within the Philippines. It is therefore necessary to explore how differences in the value of elasticity affect the projected benefit values of the model. This sensitivity analysis is restricted to varying only the elasticity of supply because it has a greater effect than varying the elasticity of demand on the projected benefits.

The elasticity of supply for *Bt* Eggplant is assumed to be 0.50 based on the production environment and high seasonality of this fruit. The elasticity was varied from 0.25 to 0.75. The elasticity of supply for MVR Tomato is assumed to be 0.75 and was varied from 0.50 to 1.00. Yorobe chose a value of 0.80 for the supply elasticity of Papaya. This value was varied from 0.40 to 1.00. *Bt* Rice was discussed in previous studies to have an elasticity of supply as low as 0.3 and as high as 0.95. The value used for this study, based on Mamaril, was 0.95. The sensitivity analysis varied the supply elasticity from 0.3 to 1.00 (Table 3.5).

**Table 3.5. Elasticity of Supply Sensitivity Analysis Values**

| Bt Eggplant | MVR Tomato | Bt Rice | PRSV Papaya |
|---|---|---|---|
| **0.50** | **0.75** | **0.95** | **0.80** |
| 0.40 | 0.50 | 0.96 | 0.90 |
| 0.25 | 0.60 | 0.94 | 1.00 |
| 0.60 | 0.70 | 0.60 | 0.60 |
| 0.75 | 0.80 | 0.30 | 0.40 |
| | 0.90 | 1.00 | |
| | 1.00 | | |

The cost of regulation assumed for each commodity in the base model is based on the projection of scientists and other experts. Because the products have not yet completed the regulatory process, cost projections are varied to show the effect on the benefits of GMO research. For each commodity, the benefits were calculated at the assumed cost, followed by 75% of the assumed cost, 125% of the cost, and then double and quadruple the cost. According to experts, there are many reasons for which the regulatory costs might differ from the estimates. An increase in expenses might first result from the need for capital improvements. These improvements would include the cost of building new facilities as was the case for rice research at PhilRice. In that case there was an expense of $20,000 for a new confined field, $30,000 for a new screen-house, and $40,000 for new laboratory facilities. When the research is being conducted by the public sector, there is an estimated savings of approximately 25%-30% due to the lack of profit seeking behavior. An even greater savings of 50% is estimated to occur when the private and public sector work together. This combination allows for the public trust that is given to the public sector to be combined with the technical efficiency of the private sector. The expense of public relations can increase expenses by as much as 25%.

The intended end use of each product does not affect the cost of regulation because each product is treated as though it were meant for human consumption. The reason for this treatment is that all products, edible or not, have the potential to come in contact with consumable products. For example, cotton is used in tea bags. The final issue to be addressed with regards to regulatory cost is the difference in cost for a product meant for domestic consumption versus export. According to the experts interviewed, exportation does not change the regulatory process or its costs. Each GMO is regulated to the highest possible standards so that the each product will be acceptable to as many destinations as possible. There are other cost differences that are not addressed in this sensitivity analysis, but will be addressed modifying the assumed time required to complete the regulatory work. The costs, expressed in US dollars, for each of the alternatives discussed above are presented in table 3.6.

**Table 3.6. Regulatory Cost Variations Expressed in US Dollars and Years**

| | Base Assumption | | 75% of Base | | 125% of Base | | Double Base | | Quadruple Base | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cost | Time | Cost | Time | Cost | Time | Cost | Time | Cost | Time |
| | | | | | **Bt Eggplant** | | | | | |
| **containment** | 90,000 | 2 | 67,500 | 2 | 112,500 | 2 | 180,000 | 2 | 360,000 | 2 |
| **ltd field trial** | 100,000 | 1 | 75,000 | 1 | 125,000 | 1 | 200,000 | 1 | 400,000 | 1 |
| **multi-location ft** | 100,000 | 1 | 75,000 | 1 | 125,000 | 1 | 200,000 | 1 | 400,000 | 1 |
| **commercialization** | 95,000 | 1 | 71,250 | 1 | 118,750 | 1 | 190,000 | 1 | 380,000 | 1 |
| | | | | | **MVR Tomato** | | | | | |
| **containment** | 90,000 | 2 | 67,500 | 2 | 112,500 | 2 | 180,000 | 2 | 360,000 | 2 |
| **ltd field trial** | 100,000 | 1 | 75,000 | 1 | 125,000 | 1 | 200,000 | 1 | 400,000 | 1 |
| **multi-location ft** | 100,000 | 1 | 75,000 | 1 | 125,000 | 1 | 200,000 | 1 | 400,000 | 1 |
| **commercialization** | 95,000 | 1 | 71,250 | 1 | 118,750 | 1 | 190,000 | 1 | 380,000 | 1 |
| | | | | | **Bt Rice** | | | | | |
| **containment** | 20,800 | 1 | 15,600 | 1 | 26,000 | 1 | 41,600 | 1 | 83,200 | 1 |
| **ltd field trial** | 446,700 | 1 | 335,025 | 1 | 558,375 | 1 | 893,400 | 1 | 1,786,800 | 1 |
| **multi-location ft** | 105,000 | 2 | 78,750 | 2 | 131,250 | 2 | 210,000 | 2 | 420,000 | 2 |
| **commercialization** | 13,180 | 1 | 9,885 | 1 | 16,475 | 1 | 26,360 | 1 | 52,720 | 1 |
| | | | | | **PRSV Papaya** | | | | | |
| **containment** | 20,000 | 2 | 15,000 | 2 | 25,000 | 2 | 40,000 | 2 | 80,000 | 2 |
| **ltd field trial** | 45,000 | 1 | 33,750 | 1 | 56,250 | 1 | 90,000 | 1 | 180,000 | 1 |
| **multi-location ft** | 42,000 | 2 | 31,500 | 2 | 52,500 | 2 | 84,000 | 2 | 168,000 | 2 |
| **commercialization** | 30,000 | 1 | 22,500 | 1 | 37,500 | 1 | 60,000 | 1 | 120,000 | 1 |

The effect of varying the length of the regulatory period was examined by lagging first year of adoption, by one, two or three years from the base scenario. This analysis was followed by the opposite scenario in which the commercialization date was pushed forward by one, two or three years earlier than the base scenario. The time lags and gains chosen were based on the opinions of experts on where time might be saved within the regulatory process and what events might cause a delay in release of a product.

The first prospect for time savings is the source of the product. In the event that a product is donated or has already been developed in another country, much of the research to develop the product in a Filipino strain of the plant can be skipped as well as many laboratory tests. This time savings is limited to the regulatory steps that occur before the contained field trial. This limitation is due to the fact that environmental tests can not be done outside of the Philippines with the same assurance as doing them on location. A second source of time savings can come from specialization. Currently everything, with respect to meeting regulations, is done by scientists including all paperwork and correspondence with the NCBP. Allowing scientists to stick to their area of expertise while assigning other personnel to the regulatory document preparation and correspondence might save up to 10% of the cost. A third source of time savings is increased efficiency that occurs with experience. As scientists and regulators become more experienced and more products make it through the various regulatory steps, all people involved in the process should become more proficient.

The potential sources of commercialization delays are far more numerous than those for time savings. These sources include the repetition of tests, review time by the

NCBP, information requests by regulators, and lack of clarity with respect to the requirements of the NCBP. One example of something that can cause a time delay is an NCBP request of more information from a previous generation. Under the containment rules of the NCBP, it is required that each generation, $T_n$, of the plant be destroyed once any and all tests are completed and the next generation, $T_{n+1}$, has been produced. In the instance of an information request from the $T_0$ generation when the scientists are testing the $T_3$ generation, $T_3$ then reverts to being the $T_0$ generation and three more generations of the plant must be produced, resulting in a time loss of three growing seasons. With a 3 month growing season, the result would be a loss of one year. In the presence of a 1 year growing season such as papaya's, the result would be a loss of 3 years. The duplication of tests is another source of time delay. An example of this is the agro-morphology, or parent to progeny, test that is being duplicated by separate tests. A lack of clarity creates time delays by encouraging scientists to gather extra information in anticipation of possible later requests by the NCBP. An inherent delay is created by the NCBP review panel schedule, as it meets only once a month. Each time the NCBP requests information about a product under review, there is a delay of at least one meeting, translating to at least one month. In many cases this delay can be avoided by the attendance of a researcher at the NCBP meeting during which the he or she might answer any questions the panel has about the product that doesn't require further physical testing. Finally, less significant delays can occur during the formation of the IBC if the required personnel is not available.

# Chapter IV. Results and Discussion

This section discusses the results of the base model as well as the sensitivity analysis. It begins by presenting the results of the economic surplus analysis for the base case. The results of the sensitivity analysis described in the previous section are then discussed. The discussion begins with the results of altering the elasticity of supply, followed by the regulatory cost changes. Finally, the sensitivity analysis is presented for the time to release or commercialization of each commodity.

## IV A. Base Model Results

The base models for this study are with the models used by Yorobe (2005), Mamaril, Francisco (2006) and, Mamaril and Norton (2006) with the cost and time of the regulatory process adjusted to reflect the information presented above. NPV's are calculated using two different discount rates, 3% and 5%. Table 4.1 displays the base values for each of these four commodities in US dollars. PRSV Papaya and *Bt* Rice do not include a value for change in consumer surplus due to the use of a small open economy assumption.

**Table 4.1. Base Model Results Including Regulatory Costs (US$)**

| | Bt Eggplant | MVR Tomato | Bt Rice | PRSV Papaya |
|---|---|---|---|---|
| **Δ*CS*** | $15,697,549 | $32,257,121 | n/a | n/a |
| **Δ*PS*** | $25,116,078 | $19,354,272 | $418,338,568 | $353,772,959 |
| **Δ*TS*** | $40,813,627 | $51,611,393 | $418,338,568 | $353,772,959 |
| **Res Cost** | $580,000 | $454,000 | $888,729 | $120,370 |
| **Reg Costs** | $475,000 | $475,000 | $690,680 | $199,000 |
| **Total Costs** | $1,055,000 | $929,000 | $1,579,409 | $319,370 |
| **Net Benefit** | $39,758,627 | $50,682,393 | $416,759,159 | $353,453,589 |
| **NPV 5%** | $20,466,196 | $33,474,446 | $257,167,618 | $240,197,527 |
| **NPV 3%** | $26,594,053 | $25,551,732 | $188,818,834 | $187,042,929 |
| **IRR** | 50.3% | 55.7% | 68.80% | 118.5% |

All of the benefit measurements are sizeable, demonstrating that the benefits significantly outweigh the costs. *Bt* eggplant results in the smallest benefits with an internal rate of return of 50.3% and at 5 and 3 percent rates respectively, an NPV of $20.4 million and $26.5 million. Next in benefit values is MVR tomato with an IRR of 55.7%, and at 5% and 3% rates, NPVs of $33.4 million and $25.5 million. The returns in the open economy models for *Bt* rice and PRSV papaya are significantly greater. *Bt* rice resulted in an IRR of 70.7% while PRSV papaya resulted in an even greater value of 118.5%. Their respective NPVs were $298.6 million and $240.1 million at a rate of 5%. At 3% their NPVs are a slightly smaller $220.3 million and $187.0 million respectively.

## IV B. Sensitivity Analysis for the Elasticity of Supply

A sensitivity analysis for the elasticity of supply demonstrates how changing its value affects the benefits. As discussed in the previous chapter, the values of the elasticity of supply were varied upwards and downwards. The results were an increase in benefits when the elasticity of supply was decreased and a decrease in benefits as the elasticity of supply became larger. The full results are presented in Table 4.2.

**Table 4.2. Sensitivity Analysis Results for the Elasticity of Supply (US$)**

| ε | ΔCS | ΔPS | NPV 5% | NPV 3% | IRR |
|---|---|---|---|---|---|
| | | | **Bt Eggplant** | | |
| **0.50** | **15,697,549** | **25,116,078** | **20,466,196** | **26,594,053** | **50.3%** |
| 0.40 | 16,612,485 | 33,224,970 | 25,173,368 | 32,674,308 | 53.4% |
| 0.25 | 18,320,680 | 58,626,176 | 39,314,286 | 50,940,330 | 60.6% |
| 0.60 | 14,916,026 | 19,888,035 | 17,331,313 | 22,544,758 | 47.8% |
| 0.75 | 13,936,372 | 14,865,463 | 14,200,186 | 18,500,352 | 44.8% |
| | | | **MVR Tomato** | | |
| **0.75** | **31,108,080** | **18,664,848** | **31,234,484** | **23,792,331** | **52.9%** |
| 0.50 | 38,960,368 | 35,064,331 | 47,335,774 | 36,132,581 | 59.2% |
| 0.60 | 35,347,535 | 26,510,651 | 39,258,309 | 29,941,979 | 56.4% |
| 0.70 | 32,392,512 | 20,823,758 | 33,520,675 | 25,544,541 | 53.9% |
| 0.80 | 29,930,913 | 16,836,139 | 29,238,720 | 22,262,701 | 51.9% |
| 0.90 | 27,848,846 | 13,924,423 | 25,923,015 | 19,721,385 | 50.1% |
| 1.00 | 26,064,926 | 11,729,217 | 23,280,947 | 17,696,347 | 48.5% |
| | | | **Bt Rice** | | |
| **0.95** | | **418,338,568** | **257,167,618** | **188,818,834** | **68.80%** |
| 0.96 | | 415,384,200 | 255,341,396 | 187,475,934 | 68.66% |
| 0.94 | | 421,355,796 | 259,032,697 | 190,190,306 | 68.93% |
| 0.60 | | 583,783,200 | 359,436,075 | 264,021,212 | 75.39% |
| 0.30 | | 1,032,847,200 | 637,021,886 | 468,141,953 | 87.58% |
| 1.00 | | 404,157,600 | 248,401,751 | 182,372,916 | 68.13% |
| | | | **PRSV Papaya** | | |
| **0.80** | | **171,976,074** | **116,630,699** | **90,806,346** | **102.5%** |
| 0.90 | | 151,780,918 | 102,904,076 | 80,115,731 | 99.9% |
| 1.00 | | 135,626,414 | 91,923,866 | 71,564,080 | 97.6% |
| 0.60 | | 232,569,637 | 157,816,013 | 122,882,401 | 109.1% |
| 0.40 | | 353,772,959 | 240,197,527 | 187,042,929 | 118.5% |

## IV C. Regulatory Cost Simulation

The cost sensitivity analysis begins with the base model that includes the cost of regulation. The cost values are then adjusted as described in the model sensitivity analysis section, leaving all other assumptions equal to the base model assumptions. The importance of this sensitivity analysis stems from a need to demonstrate the effects of changes in costs on the benefits experienced within the Filipino economy. The result for each commodity is a marginal change in the internal rate of return and net present value at both discount rates. Changing the cost of regulation has little effect on producer or consumer surplus. A 25% increase or decrease in the cost of regulation results in a respective increase or decrease in the net present value of less than $100,000 or less than one percent. The greatest change in internal rate of return is 0.6 percent *Bt* eggplant while PRSV papaya had the smallest change of just 0.1 percent. When the change in cost is increased by 200%, the loss is no more than 2.5% of the net present value. The internal rate of return is reduced by only one to two percent for each of the commodities. Finally, an increase of 400% in costs is simulated resulting in a decrease in the internal rate of return between two and seven percent. The largest loss is experienced by *Bt* eggplant followed by *Bt* rice, MVR tomato and lastly PRSV papaya. Monetarily the results are equivalent to a loss of benefits between $500,000 and $1,000,000. As can be seen by the results detailed in table 4.3, changes in the direct cost of regulation do not affect the socioeconomic benefits of the research very much. As will be shown next, this is not the case for changes in the date of release or commercialization.

**Table 4.3. Sensitivity Analysis Results for the Cost of Regulation (US$)**

| | **Base** | **75%** | **125%** | **200%** | **400%** |
|---|---|---|---|---|---|
| | | | **Bt Eggplant** | | |
| Δ*CS* | **15,697,549** | 15,697,549 | 15,697,549 | 15,697,549 | 15,697,549 |
| Δ*PS* | **25,116,078** | 25,116,078 | 25,116,078 | 25,116,078 | 25,116,078 |
| Δ*TS* | **40,813,627** | 40,813,627 | 40,813,627 | 40,813,627 | 40,813,627 |
| Res Cost | **580,000** | 580,000 | 580,000 | 580,000 | 580,000 |
| Reg Costs | **475,000** | 356,250 | 593,750 | 950,000 | 1,900,000 |
| Total Costs | **1,055,000** | 936,250 | 1,173,750 | 1,530,000 | 2,480,000 |
| Net Benefit | **39,758,627** | 39,877,377 | 39,639,877 | 39,283,627 | 38,333,627 |
| NPV 5% | **20,466,196** | 20,550,612 | 20,381,779 | 20,128,529 | 19,453,196 |
| NPV 3% | **26,594,053** | 26,690,570 | 26,497,536 | 26,207,985 | 25,435,849 |
| IRR | **50.3%** | 50.9% | 49.7% | 47.9% | 43.7% |
| | | | **MVR Tomato** | | |
| Δ*CS* | **32,257,121** | 32,257,121 | 32,257,121 | 31,108,080 | 31,108,080 |
| Δ*PS* | **19,354,272** | 19,354,272 | 19,354,272 | 18,664,848 | 18,664,848 |
| Δ*TS* | **51,611,393** | 51,611,393 | 51,611,393 | 49,772,928 | 49,772,928 |
| Res Cost | **454,000** | 454,000 | 454,000 | 454,000 | 454,000 |
| Reg Costs | **475,000** | 356,250 | 593,750 | 950,000 | 1,900,000 |
| Total Costs | **929,000** | 810,250 | 1,047,750 | 1,404,000 | 2,354,000 |
| Net Benefit | **50,682,393** | 50,801,143 | 50,563,643 | 48,368,928 | 47,418,928 |
| NPV 5% | **33,474,446** | 33,562,773 | 33,386,119 | 31,941,098 | 31,234,484 |
| NPV 3% | **25,551,732** | 25,624,654 | 25,478,810 | 24,375,710 | 23,792,331 |
| IRR | **55.7%** | 55.9% | 55.5% | 54.5% | 52.9% |
| | | | **Bt Rice** | | |
| Δ*PS* | **418,338,568** | 481,723,200 | 481,723,200 | 481,723,200 | 481,723,200 |
| Res Cost | **888,729** | 888,729 | 888,729 | 888,729 | 888,729 |
| Reg Costs | **690,680** | 518,010 | 863,350 | 1,381,360 | 2,762,720 |
| Total Costs | **1,579,409** | 1,406,739 | 1,752,079 | 2,270,089 | 3,651,449 |
| Net Benefit | **416,759,159** | 480,316,461 | 479,971,121 | 479,453,111 | 478,071,751 |
| NPV 5% | **257,167,618** | 298,836,352 | 298,542,591 | 298,101,948 | 296,926,903 |
| NPV 3% | **188,818,834** | 220,505,855 | 220,241,351 | 219,844,595 | 218,786,578 |
| IRR | **68.80%** | 71.26% | 70.24% | 68.77% | 65.11% |
| | | | **PRSV Papaya** | | |
| Δ*PS* | **353,772,959** | 353,772,959 | 353,772,959 | 353,772,959 | 353,772,959 |
| Res Cost | **120,370** | 120,370 | 120,370 | 120,370 | 120,370 |
| Reg Costs | **199,000** | 149,250 | 248,750 | 398,000 | 796,000 |
| Total Costs | **319,370** | 269,620 | 369,120 | 518,370 | 916,370 |
| Net Benefit | **353,453,589** | 353,503,339 | 353,403,839 | 353,254,589 | 352,856,589 |
| NPV 5% | **240,197,527** | 240,237,091 | 240,157,962 | 240,039,268 | 239,722,751 |
| NPV 3% | **187,042,929** | 187,077,053 | 187,008,806 | 186,906,435 | 186,633,448 |
| IRR | **118.5%** | 118.6% | 118.3% | 117.7% | 116.3% |

## IV D. Effects of Varying Regulatory Time

The sensitivity analysis for changes in the release date is based on the possible losses or gains in time that can occur within the regulatory process. As discussed in the model section, these losses include the value of time losses due to factors such as NCBP requests for information, while the gains reflect factors such as specialization by scientists and other professionals working on the research. A loss of one to three years is well within the limits of time loss that might be expected. A gain of one or two years is easily conceivable while a gain of three years is far less likely, but it is not outside of the realm of possibility. These values were chosen for their likelihood of occurrence based on the opinions of scientists and to demonstrate how significant the change in benefits is from one year to the next. For each year lost, the internal rate of return of *Bt* eggplant decreases by about 8%, while MVR tomato experiences a slightly larger loss of approximately 9% per year. There is a larger loss still for *Bt* rice equal to a decrease in the internal rate of return of 10%. The largest loss is experienced by PRSV papaya at a rate of 18% per year. In comparison, a 400% increase in the cost of regulation only resulted in a decrease of 2.2% in the IRR. The results of the gain in time are equal and opposite to the loss, where *Bt* eggplant gains approximately 8% each year, MVR tomato gains 9%, *Bt* rice gains 10% and finally PRSV papaya gains a staggering 18% per year in the internal rate of return.

The changes in net present value experienced for each year lost or gained in the regulatory process vary from year to year for each of the four commodities. The smallest loss and gain in net present value is experienced by *Bt* eggplant with a respective initial loss or gain of approximately $7,000,000 the first year. In the presence of a two year loss or gain, the net present value is changed by roughly $14.5 million and at three years the total change is just under $21 million. If the loss of time were extended out to 5 years, the net present value at both 3% and 5% would become negative with an internal rate of return in the positive single digits. MVR Tomato experiences a loss of approximately $9 million each of the first two years and a loss of just under $6 million when release is delayed by 3 years. When the change of release date is reversed so that MVR Tomato gains a year, NPV is increased by $9 million the first year, another $8 million the second year and $4 million the third year. The result is a maximum loss that results in a still positive NPV of slightly larger than $1.8 million or a maximum NPV of slightly less than $47 million, assuming a discount rate of 3%. The changes for the open economy model of PRSV papaya and *Bt* rice are significantly larger in value, but proportionally similar to those of MVR tomato and *Bt* eggplant. For the first year of lag, the NPV of *Bt* rice at 3% discount rate decreases by $25 million. The first year loss is followed by losses of $23 million each for the second and third years lagged. As each year of gain is simulated, the results are reversed with gains similar to the losses previously described. The largest numerical losses and gains are experienced by PRSV papaya. For the first year lost, NPV decreases by approximately $50 million. The second year lost results in a smaller change of $40 million followed by a loss of $30 million when commercialization is pushed back by 3 years. The values for the gains are similar. The changes in value of each of the commodities, although different in value, are virtually equal proportionately. The results for the release date sensitivity analysis are demonstrated in table 4.4.

**Table 4.4. Sensitivity Analysis Results of Varying GMO Release Date (US$/MT)**

| | Base | Lag 1 Year | Lag 2 Years | Lag 3 Years | Gain 1 Year | Gain 2 Years | Gain 3 Years |
|---|---|---|---|---|---|---|---|
| | | | | **Bt Eggplant** | | | |
| D*CS* | **15,697,549** | 11,713,850 | 7,485,850 | 3,939,102 | 19,438,054 | 22,936,473 | 26,193,913 |
| D*PS* | **25,116,078** | 18,742,160 | 11,977,360 | 6,302,563 | 31,100,887 | 36,698,357 | 41,910,261 |
| D*TS* | **40,813,627** | 30,456,010 | 19,463,209 | 10,241,665 | 50,538,941 | 59,634,831 | 68,104,174 |
| Res Cost | **580,000** | 580,000 | 580,000 | 580,000 | 580,000 | 580,000 | 580,000 |
| Reg Costs | **475,000** | 475,000 | 475,000 | 475,000 | 475,000 | 475,000 | 475,000 |
| Total Costs | **1,055,000** | 1,055,000 | 1,055,000 | 1,055,000 | 1,055,000 | 1,055,000 | 1,055,000 |
| Net Benefit | **39,758,627** | 29,401,010 | 18,408,209 | 9,186,665 | 49,483,941 | 58,579,831 | 67,049,174 |
| NPV 5% | **20,466,196** | 14,707,235 | 8,931,527 | 4,242,285 | 26,208,955 | 31,936,088 | 37,648,199 |
| NPV 3% | **26,594,053** | 19,338,452 | 11,898,354 | 5,778,747 | 33,661,470 | 40,536,906 | 47,216,449 |
| IRR | **50.3%** | 42.7% | 34.8% | 25.8% | 58.6% | 68.8% | 82.3% |
| | | | | **MVR Tomato** | | | |
| D*CS* | **32,257,121** | 21,401,081 | 10,545,041 | 3,411,485 | 41,964,120 | 50,536,175 | 54,575,898 |
| D*PS* | **19,354,272** | 12,840,648 | 6,327,025 | 2,046,891 | 25,178,472 | 30,321,705 | 32,745,539 |
| D*TS* | **51,611,393** | 34,241,729 | 16,872,065 | 5,458,376 | 67,142,591 | 80,857,880 | 87,321,437 |
| Res Cost | **454,000** | 454,000 | 454,000 | 454,000 | 454,000 | 454,000 | 454,000 |
| Reg Costs | **475,000** | 593,750 | 593,750 | 593,750 | 593,750 | 593,750 | 593,750 |
| Total Costs | **929,000** | 1,047,750 | 1,047,750 | 1,047,750 | 1,047,750 | 1,047,750 | 1,047,750 |
| Net Benefit | **50,682,393** | 33,193,979 | 15,824,315 | 4,410,626 | 66,094,841 | 79,810,130 | 86,273,687 |
| NPV 5% | **33,474,446** | 21,564,845 | 10,087,879 | 2,656,761 | 44,381,991 | 54,542,175 | 59,672,688 |
| NPV 3% | **25,551,732** | 16,272,980 | 7,505,523 | 1,884,065 | 34,260,598 | 42,607,991 | 46,991,602 |
| IRR | **55.7%** | 46.6% | 35.6% | 20.7% | 64.3% | 74.2% | 80.5% |

**Table 4.4. Sensitivity Analysis Results of Varying GMO Release Date (US$/MT) (continued)**

| | Base | Lag 1 Year | Lag 2 Years | Lag 3 Years | Gain 1 Year | Gain 2 Years | Gain 3 Years |
|---|---|---|---|---|---|---|---|
| **Bt Rice** | | | | | | | |
| Δ*PS* | **418,338,568** | 371,856,505 | 325,374,442 | 278,892,379 | 464,820,632 | 511,302,695 | 557,784,758 |
| Res Cost | **888,729** | 888,729 | 888,729 | 888,729 | 888,729 | 888,729 | 888,729 |
| Reg Costs | **690,680** | 690,680 | 690,680 | 690,680 | 690,680 | 690,680 | 690,680 |
| Total Costs | **1,579,409** | 1,579,409 | 1,579,409 | 1,579,409 | 1,579,409 | 1,579,409 | 1,579,409 |
| Net Benefit | **416,759,159** | 370,277,096 | 323,795,033 | 277,312,970 | 463,241,223 | 509,723,286 | 556,205,349 |
| NPV 5% | **257,167,618** | 225,377,141 | 194,512,599 | 164,547,024 | 289,911,811 | 323,638,329 | 358,376,643 |
| NPV 3% | **188,818,834** | 163,873,966 | 140,116,949 | 117,491,219 | 215,010,945 | 242,512,661 | 271,389,463 |
| IRR | **68.80%** | 60.05% | 53.31% | 47.86% | 80.79% | 98.45% | 127.27% |
| **PRSV Papaya** | | | | | | | |
| Δ*PS* | **353,772,959** | 263,573,319 | 186,619,463 | 122,348,297 | 457,781,477 | 561,789,996 | 665,798,514 |
| Res Cost | **120,370** | 120,370 | 120,370 | 120,370 | 120,370 | 120,370 | 120,370 |
| Reg Costs | **199,000** | 199,000 | 199,000 | 199,000 | 199,000 | 199,000 | 199,000 |
| Total Costs | **319,370** | 319,370 | 319,370 | 319,370 | 319,370 | 319,370 | 319,370 |
| Net Benefit | **353,453,589** | 263,253,949 | 186,300,093 | 122,028,927 | 457,462,107 | 561,470,626 | 665,479,144 |
| NPV 5% | **240,197,527** | 176,984,170 | 123,866,313 | 80,199,012 | 314,170,678 | 390,363,024 | 468,841,140 |
| NPV 3% | **187,042,929** | 136,803,018 | 95,023,529 | 61,043,627 | 246,437,143 | 308,801,067 | 374,283,188 |
| IRR | **118.5%** | 102.2% | 88.8% | 76.8% | 139.7% | 169.5% | 214.5% |

Unlike the scenarios in which cost is changed, the scenarios in which time delays or gains occur create changes in the values for producer surplus. The results are similar to the changes in NPV and IRR where the changes in value are each proportionate to each other even though their values differ greatly. Ultimately the result is that losses or gains created by changes in the date of commercialization are of far greater consequence than changes in the physical cost of regulation.

# Chapter V. Summary and Conclusions

## V A. Summary

This study evaluated the economic impact of the GMO regulatory process on the change in producer surplus, the net present value and the internal rate return using an economic surplus model. The evaluation was carried out for four different commodities in the Philippines, *Bt* rice, *Bt* eggplant, PRSV papaya and MVR tomato. The base parameters were derived from the studies of *Bt* rice by Mamaril and Norton, PRSV papaya by Yorobe, *Bt* eggplant by Francisco and MVR tomato by Mamaril and by interviewing scientists, government officials and other experts in the field. The estimated base scenario for the open economy model resulted in a change in producer surplus, as a result of the GMO research, of $418.3 million for *Bt* rice and $353.7 million for PRSV papaya. The closed economy model for *Bt* eggplant has a projected change in producer surplus of $25.1 million and a change in total surplus of $40.8 million, while the result for the change in producer surplus for MVR tomato is $19.3 million and the change in total surplus is $51.6 million. Sensitivity analysis of the results was then carried out in which the elasticity of supply, the cost of regulation, and the release date each were varied in order to show the welfare impact of such changes. The sensitivity analysis revealed limited changes in surplus when elasticity of supply and regulatory costs were changed. However, changing the date of release or commercialization resulted in sizeable changes in economic surplus.

The results of the sensitivity analysis suggest that benefits from cost reduction are minimal. The benefits are greatest when scientists are able to complete the regulatory process more quickly. The benefits of releasing a product just one year earlier are an increase of return by as much as 30%. At the very least, the goal of the scientists should be to complete the regulatory process within the estimated time period. A loss of one year is as costly as a gain of one year is beneficial, where the loss would accrue to a minimum of 15%. From a standpoint of cost and benefits, it cannot be denied that the adoption of GMO research will be economically beneficial to the Philippines. Even in the presence of a 3 year loss in the regulatory process or quadruple the regulatory costs, the benefits of adoption far outweigh the costs.

**V B. Limitations of the Study and Further Research**

While the benefits presented in this study are significant, there are a few apparent limitations. The most obvious limitation is that the regulatory costs and time requirements for each of the commodities are estimates based on the experience of the scientists interviewed. Once their research is completed, the benefits could be recalculated with the actual values for time to completion and regulatory costs. As has already been discussed in this study, there are inconsistent values for the regulatory costs from one study to another. Fortunately, this inconsistency was addressed in the sensitivity analysis and was found to have little effect on the overall results. This study was not able to include monitoring costs in its research. Further studies might include these costs to better approximate the costs experienced during research and development.

Although benefits have been clearly shown to outweigh costs throughout the results of the study, the costs could still be prohibitive for a developing country or an NGO if the benefits are very uncertain. This effect of uncertainty is evidenced by the cancellation of the MVR tomato research during the commencement of this study.

Unfortunately, due to funding cutbacks, scientists were no longer able to continue their research of MVR Tomato.

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## Appendix A: Website References

Executive Order 430
http://www.ncbp.dost.gov.ph/index.php?option=com_content&task=view&id=42&Itemid=74

Bureau of Agricultural Statistics
http://www.bas.gov.ph/

# Appendix B:  Economic Surplus Model Tables

**Economic Surplus Model Spreadsheet** *(Alston, Norton & Pardey, 1995)* *Small Open Economy: PRSV Papaya*

| A | B | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR T | Elasticity of Supply e | Expected Yield Change kg/ha E(dY) | Gross Cost Change per ton E(Y)/e | Prop Change in Input Cost per ha E(C) | Prop Change in Input Cost per ton E(C)/(1+E(Y)) | Net Cost Change | Probability of Success | Rate of Adoption | Depreciation Rate of Adoption | Depreciation Factor Kt | Price US $ 1USD=P54 Pw | Quantity (base qty) MT Qo | Change in Producer Surplus dPS=dTS | Research Cost US$ | Regulatory Costs US$ | Total Costs | Net Benefit | Net Present Value 3% NPV | Net present value 5% NPV | Internal Rate of Return IRR |
| | *known* | +/- | D/B | +/- | F/(1+D) | E-G | *known* | *known* | *known* | H*I*J*K | *known* | *known* | M*N*L(1+0.5*L*B) | *known* | *known* | *P+Q* | O-R | NPV(r,Ben) | NPV(r,BEN) | IRR(Ben,r) |
| 2003 | 0.80 | 0.77 | 0.96 | 0.08 | 0.05 | 0.92 | 0.83 | 0.00 | 1.00 | 0.000 | 392.00 | 159000 | 0 | 41,667 | 0 | 41,667 | (41,667) | 125,726,944 | 97,891,086 | 104.1% |
| 2004 | 0.80 | 0.77 | 0.96 | 0.08 | 0.05 | 0.92 | 0.83 | 0.00 | 1.00 | 0.000 | 392.00 | 159000 | 0 | 23,148 | 0 | 23,148 | (23,148) | | | |
| 2005 | 0.80 | 0.77 | 0.96 | 0.08 | 0.05 | 0.92 | 0.83 | 0.00 | 1.00 | 0.000 | 392.00 | 159000 | 0 | 23,148 | 0 | 23,148 | (23,148) | | | |
| 2006 | 0.80 | 0.77 | 0.96 | 0.08 | 0.05 | 0.92 | 0.83 | 0.00 | 1.00 | 0.000 | 392.00 | 159000 | 0 | 32,407 | 0 | 32,407 | (32,407) | | | |
| 2007 | 0.80 | 0.77 | 0.96 | 0.08 | 0.05 | 0.92 | 0.83 | 0.00 | 1.00 | 0.000 | 392.00 | 159000 | 0 | 0 | 20,000 | 20,000 | (20,000) | | | |
| 2008 | 0.80 | 0.77 | 0.96 | 0.08 | 0.05 | 0.92 | 0.83 | 0.00 | 1.00 | 0.000 | 392.00 | 159000 | 0 | 0 | 20,000 | 20,000 | (20,000) | | | |
| 2009 | 0.80 | 0.77 | 0.96 | 0.08 | 0.05 | 0.92 | 0.83 | 0.00 | 1.00 | 0.000 | 392.00 | 159000 | 0 | 0 | 45,000 | 45,000 | (45,000) | | | |
| 2010 | 0.80 | 0.77 | 0.96 | 0.08 | 0.05 | 0.92 | 0.83 | 0.00 | 1.00 | 0.000 | 392.00 | 159000 | 0 | 0 | 42,000 | 42,000 | (42,000) | | | |
| 2011 | 0.80 | 0.77 | 0.96 | 0.08 | 0.05 | 0.92 | 0.83 | 0.00 | 1.00 | 0.000 | 392.00 | 159000 | 0 | 0 | 42,000 | 42,000 | (42,000) | | | |
| 2012 | 0.80 | 0.77 | 0.96 | 0.08 | 0.05 | 0.92 | 0.83 | 0.30 | 1.00 | 0.228 | 392.00 | 159000 | 15,536,899 | 0 | 30,000 | 30,000 | 15,506,899 | | | |
| 2013 | 0.80 | 0.77 | 0.96 | 0.08 | 0.05 | 0.92 | 0.83 | 0.40 | 1.00 | 0.305 | 392.00 | 159000 | 21,293,941 | 0 | 0 | 0 | 21,293,941 | | | |
| 2014 | 0.80 | 0.77 | 0.96 | 0.08 | 0.05 | 0.92 | 0.83 | 0.50 | 1.00 | 0.381 | 392.00 | 159000 | 27,340,020 | 0 | 0 | 0 | 27,340,020 | | | |
| 2015 | 0.80 | 0.77 | 0.96 | 0.08 | 0.05 | 0.92 | 0.83 | 0.60 | 1.00 | 0.457 | 392.00 | 159000 | 33,675,137 | 0 | 0 | 0 | 33,675,137 | | | |
| 2016 | 0.80 | 0.77 | 0.96 | 0.08 | 0.05 | 0.92 | 0.83 | 0.70 | 1.00 | 0.533 | 392.00 | 159000 | 40,299,291 | 0 | 0 | 0 | 40,299,291 | | | |
| 2017 | 0.80 | 0.77 | 0.96 | 0.08 | 0.05 | 0.92 | 0.83 | 0.80 | 1.00 | 0.609 | 392.00 | 159000 | 47,212,483 | 0 | 0 | 0 | 47,212,483 | | | |
| | | | | | | | | | | | | | **D*PS*** | **Res Costs** | **Reg Costs** | **Total Costs** | **Net Benefit** | **NPV 3%** | **NPV 5%** | **IRR** |
| | | | | | | | | | | | | | 185,357,770 | 120,370 | 199,000 | 319,370 | ########## | 125,726,944 | 97,891,086 | 104.1% |

**Economic Surplus Model Spreadsheet** *(Alston, Norton & Pardey, 1995)* *Small Open Economy: Bt Rice*

| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | | U |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR T | Elasticity of Supply e | Elasticity of Demand n | Expected Yield Change kg/ha E(dY) | Gross Cost Change per ton E(Y)/e | Prop Change in Input Cost per ha E(C) | Prop Change in Input Cost per ton E(C)/(1+E(Y)) | Net Cost Change | Probability of Success | Rate of Adoption A | Depreciation Rate of Adoption | Depreciation Factor Kt=(E(Y)/e)*A | Price USD/MT 1USD=44.35Php Pw | Quantity (base qty) MT Qo | Change in Producer Surplus dPS=dTS | Research Cost USD | Regulatory Cost USD | Regulatory + Research Costs | Net Benefit | Net Present Value 3% NPV | Net present value 5% NPV | Internal Rate of Return IRR |
| | *known* | *known* | +/- | D/B | +/- | F/(1+D) | E-G | *known* | *known* | *known* | E*J | *known* | *known* | M*N*L(1+0.5*L*B) | *known* | *known* | *P+Q* | O-R | NPV(r,Ben) | NPV(r,BEN) | IRR(Ben,r) |
| 2000 | 0.95 | 0.93 | 0.024 | 0.025 | 0.00 | 0.00 | 0.03 | 1.00 | 0.00 | 1.00 | 0.000 | 180.00 | 10,500,000 | 0 | 296,243 | 0 | 296,243 | (296,243) | 127,068,014 | 98,470,727 | 68.07% |
| 2001 | 0.95 | 0.93 | 0.024 | 0.025 | 0.00 | 0.00 | 0.03 | 1.00 | 0.00 | 1.00 | 0.000 | 180.00 | 10,500,000 | 0 | 296,243 | 0 | 296,243 | (296,243) | | | |
| 2002 | 0.95 | 0.93 | 0.024 | 0.025 | 0.00 | 0.00 | 0.03 | 1.00 | 0.00 | 1.00 | 0.000 | 180.00 | 10,500,000 | 0 | 296,243 | 0 | 296,243 | (296,243) | | | |
| 2003 | 0.95 | 0.93 | 0.024 | 0.025 | 0.00 | 0.00 | 0.03 | 1.00 | 0.00 | 1.00 | 0.000 | 180.00 | 10,500,000 | 0 | 0 | 20,800 | 20,800 | (20,800) | | | |
| 2004 | 0.95 | 0.93 | 0.024 | 0.025 | 0.00 | 0.00 | 0.03 | 1.00 | 0.00 | 1.00 | 0.000 | 180.00 | 10,500,000 | 0 | 0 | 446,700 | 446,700 | (446,700) | | | |
| 2005 | 0.95 | 0.93 | 0.024 | 0.025 | 0.00 | 0.00 | 0.03 | 1.00 | 0.00 | 1.00 | 0.000 | 180.00 | 10,500,000 | 0 | 0 | 105,000 | 105,000 | (105,000) | | | |
| 2006 | 0.95 | 0.93 | 0.024 | 0.025 | 0.00 | 0.00 | 0.03 | 1.00 | 0.00 | 1.00 | 0.000 | 180.00 | 10,500,000 | 0 | 0 | 105,000 | 105,000 | (105,000) | | | |
| 2007 | 0.95 | 0.93 | 0.024 | 0.025 | 0.00 | 0.00 | 0.03 | 1.00 | 0.06 | 1.00 | 0.002 | 180.00 | 10,500,000 | 4,225,642 | 0 | 13,180 | 13,180 | 4,212,462 | | | |
| 2008 | 0.95 | 0.93 | 0.024 | 0.025 | 0.00 | 0.00 | 0.03 | 1.00 | 0.12 | 1.00 | 0.003 | 180.00 | 10,500,000 | 8,451,284 | 0 | 0 | 0 | 8,451,284 | | | |
| 2009 | 0.95 | 0.93 | 0.024 | 0.025 | 0.00 | 0.00 | 0.03 | 1.00 | 0.18 | 1.00 | 0.005 | 180.00 | 10,500,000 | 12,676,926 | 0 | 0 | 0 | 12,676,926 | | | |
| 2010 | 0.95 | 0.93 | 0.024 | 0.025 | 0.00 | 0.00 | 0.03 | 1.00 | 0.24 | 1.00 | 0.006 | 180.00 | 10,500,000 | 16,902,568 | 0 | 0 | 0 | 16,902,568 | | | |
| 2011 | 0.95 | 0.93 | 0.024 | 0.025 | 0.00 | 0.00 | 0.03 | 1.00 | 0.30 | 1.00 | 0.008 | 180.00 | 10,500,000 | 21,128,211 | 0 | 0 | 0 | 21,128,211 | | | |
| 2012 | 0.95 | 0.93 | 0.024 | 0.025 | 0.00 | 0.00 | 0.03 | 1.00 | 0.36 | 1.00 | 0.009 | 180.00 | 10,500,000 | 25,353,853 | 0 | 0 | 0 | 25,353,853 | | | |
| 2013 | 0.95 | 0.93 | 0.024 | 0.025 | 0.00 | 0.00 | 0.03 | 1.00 | 0.42 | 1.00 | 0.011 | 180.00 | 10,500,000 | 29,579,495 | 0 | 0 | 0 | 29,579,495 | | | |
| 2014 | 0.95 | 0.93 | 0.024 | 0.025 | 0.00 | 0.00 | 0.03 | 1.00 | 0.48 | 1.00 | 0.012 | 180.00 | 10,500,000 | 33,805,137 | 0 | 0 | 0 | 33,805,137 | | | |
| 2015 | 0.95 | 0.93 | 0.024 | 0.025 | 0.00 | 0.00 | 0.03 | 1.00 | 0.54 | 1.00 | 0.014 | 180.00 | 10,500,000 | 38,030,779 | 0 | 0 | 0 | 38,030,779 | | | |
| | | | | | | | | | | | | | | **Δ*PS*** | **Res Costs** | **Reg Costs** | **Total Costs** | **Net Benefit** | **NPV 3%** | **NPV 5%** | **IRR** |
| | | | | | | | | | | | | | | 190,153,895 | 888,729 | 690,680 | 1,579,409 | 188,574,486 | 127,068,014 | 98,470,727 | 68.07% |

**Economic Surplus Model Spreadsheet** *(Alston, Norton & Pardey, 1995)* ***Closed Economy: Tomato***

| A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR T | Elasticity of Supply e | Elasticity of Demand n | Expected Yield Change E(dY) | Gross Cost Change per ton | Prop Change in Input Cost per ha E(C) | Prop Change in Input Cost per ton | Net Cost Change | Probability of Success | Rate of Adoption | Depreciation Rate of Adoption | Depreciation Factor Kt | Price US$ 1USD=50PhP P |
| | *known* | *known* | +/- | D/B | +/- | F/(1+D) | E-G | *known* | *known* | *known* | H*I*J*K | *known* |
| 2005 | 0.75 | 0.45 | 0.67 | 0.89 | -0.10 | -0.060 | 0.953 | 0.74 | 0.00 | 1.00 | 0.000 | 215 |
| 2006 | 0.75 | 0.45 | 0.67 | 0.89 | -0.10 | -0.060 | 0.953 | 0.74 | 0.00 | 1.00 | 0.000 | 215 |
| 2007 | 0.75 | 0.45 | 0.67 | 0.89 | -0.10 | -0.060 | 0.953 | 0.74 | 0.00 | 1.00 | 0.000 | 215 |
| 2008 | 0.75 | 0.45 | 0.67 | 0.89 | -0.10 | -0.060 | 0.953 | 0.74 | 0.00 | 1.00 | 0.000 | 215 |
| 2009 | 0.75 | 0.45 | 0.67 | 0.89 | -0.10 | -0.060 | 0.953 | 0.74 | 0.00 | 1.00 | 0.000 | 215 |
| 2010 | 0.75 | 0.45 | 0.67 | 0.89 | -0.10 | -0.060 | 0.953 | 0.74 | 0.00 | 1.00 | 0.000 | 215 |
| 2011 | 0.75 | 0.45 | 0.67 | 0.89 | -0.10 | -0.060 | 0.953 | 0.74 | 0.00 | 1.00 | 0.000 | 215 |
| 2012 | 0.75 | 0.45 | 0.67 | 0.89 | -0.10 | -0.060 | 0.953 | 0.74 | 0.00 | 1.00 | 0.000 | 215 |
| 2013 | 0.75 | 0.45 | 0.67 | 0.89 | -0.10 | -0.060 | 0.953 | 0.74 | 0.00 | 1.00 | 0.000 | 215 |
| 2014 | 0.75 | 0.45 | 0.67 | 0.89 | -0.10 | -0.060 | 0.953 | 0.74 | 0.00 | 1.00 | 0.000 | 215 |
| 2015 | 0.75 | 0.45 | 0.67 | 0.89 | -0.10 | -0.060 | 0.953 | 0.74 | 0.00 | 1.00 | 0.000 | 215 |
| 2016 | 0.75 | 0.45 | 0.67 | 0.89 | -0.10 | -0.060 | 0.953 | 0.74 | 0.23 | 1.00 | 0.162 | 215 |
| 2017 | 0.75 | 0.45 | 0.67 | 0.89 | -0.10 | -0.060 | 0.953 | 0.74 | 0.47 | 1.00 | 0.332 | 215 |
| 2018 | 0.75 | 0.45 | 0.67 | 0.89 | -0.10 | -0.060 | 0.953 | 0.74 | 0.70 | 1.00 | 0.494 | 215 |
| 2019 | 0.75 | 0.45 | 0.67 | 0.89 | -0.10 | -0.060 | 0.953 | 0.74 | 0.70 | 0.90 | 0.444 | 215 |

| A | N | O | P | Q | R | S | T | U | V | W | X | Y |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR T | Prop dec in price Zt | Quantity (base qty) MT Qo | Changes in Consumer Surplus dCS | Change in Producer Surplus dPS | Change in Total Econ Surplus dTS | Research Cost US$ | Regulatory Costs US$ | Reg + Res Costs US$ | Net Benefit | Net Present Value 3% NPV | Net present Value 5% NPV | Internal Rate of Return IRR |
| | L*B/(B+C) | *known* | M*N*O[(1+0.5*N*C* | O(L-N)(1+.5*N* | L*M*O(1+.5*N*C | *known* | *known* | *S+T* | R-U | NPV(r,Ben) | NPV(r,BEN) | IRR(Ben,r) |
| 2005 | - | 152,690 | - | - | - | 62,000 | - | 62,000 | (62,000) | **31,234,484** | **23,792,331** | **52.9%** |
| 2006 | - | 152,690 | - | - | - | 82,000 | - | 82,000 | (82,000) | | | |
| 2007 | - | 152,690 | - | - | - | 62,000 | - | 62,000 | (62,000) | | | |
| 2008 | - | 152,690 | - | - | - | 62,000 | - | 62,000 | (62,000) | | | |
| 2009 | - | 152,690 | - | - | - | 62,000 | - | 62,000 | (62,000) | | | |
| 2010 | - | 152,690 | - | - | - | 62,000 | - | 62,000 | (62,000) | | | |
| 2011 | - | 152,690 | - | - | - | 62,000 | - | 62,000 | (62,000) | | | |
| 2012 | - | 152,690 | - | - | - | - | 360,000 | 360,000 | (360,000) | | | |
| 2013 | - | 152,690 | - | - | - | - | 360,000 | 360,000 | (360,000) | | | |
| 2014 | - | 152,690 | - | - | - | - | 400,000 | 400,000 | (400,000) | | | |
| 2015 | - | 152,690 | - | - | - | - | 400,000 | 400,000 | (400,000) | | | |
| 2016 | 0.101 | 152,690 | 3,411,485 | 2,046,891 | 5,458,376 | - | 380,000 | 380,000 | 5,078,376 | | | |
| 2017 | 0.207 | 152,690 | 7,133,556 | 4,280,134 | 11,413,689 | - | - | - | 11,413,689 | | | |
| 2018 | 0.309 | 152,690 | 10,856,040 | 6,513,624 | 17,369,664 | - | - | - | 17,369,664 | | | |
| 2019 | 0.278 | 152,690 | 9,706,999 | 5,824,199 | 15,531,198 | - | - | - | 15,531,198 | | | |
| | | | ***ΔCS*** | ***ΔPS*** | ***ΔTS*** | **Res Cost** | **Reg Costs** | **Total Costs** | **Net Benefit** | **NPV 3%** | **NPV 5%** | **IRR** |
| | | | 31,108,080 | 18,664,848 | 49,772,928 | 454,000 | 1,900,000 | 2,354,000 | 47,418,928 | 31,234,484 | 23,792,331 | 52.9% |

**Economic Surplus Model Spreadsheet** *(Alston, Norton & Pardey, 1995)* ***Closed Economy: Eggplant***

| A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR T | Elasticity of Supply e | Elasticity of Demand n | Expected Yield Change E(dY) | Gross Cost Change per ton | Prop Change in Input Cost per ha E(C) | Prop Change in Input Cost per ton | Net Cost Change | Probability of Success | Rate of Adoption | Depreciation Rate of Adoption | Depreciation Factor Kt | Price US$ 1USD=50PhP P |
| | *known* | *known* | +/- | D/B | +/- | F/(1+D) | E-G | *known* | *known* | *known* | H*I*J*K | *known* |
| 2004 | 0.50 | 0.80 | 0.40 | 0.80 | -0.16 | -0.114 | 0.914 | 0.70 | 0.00 | 1.00 | 0.000 | 200 |
| 2005 | 0.50 | 0.80 | 0.40 | 0.80 | -0.16 | -0.114 | 0.914 | 0.70 | 0.00 | 1.00 | 0.000 | 200 |
| 2006 | 0.50 | 0.80 | 0.40 | 0.80 | -0.16 | -0.114 | 0.914 | 0.70 | 0.00 | 1.00 | 0.000 | 200 |
| 2007 | 0.50 | 0.80 | 0.40 | 0.80 | -0.16 | -0.114 | 0.914 | 0.70 | 0.00 | 1.00 | 0.000 | 200 |
| 2008 | 0.50 | 0.80 | 0.40 | 0.80 | -0.16 | -0.114 | 0.914 | 0.70 | 0.00 | 1.00 | 0.000 | 200 |
| 2009 | 0.50 | 0.80 | 0.40 | 0.80 | -0.16 | -0.114 | 0.914 | 0.70 | 0.00 | 1.00 | 0.000 | 200 |
| 2010 | 0.50 | 0.80 | 0.40 | 0.80 | -0.16 | -0.114 | 0.914 | 0.70 | 0.00 | 1.00 | 0.000 | 200 |
| 2011 | 0.50 | 0.80 | 0.40 | 0.80 | -0.16 | -0.114 | 0.914 | 0.70 | 0.00 | 1.00 | 0.000 | 200 |
| 2012 | 0.50 | 0.80 | 0.40 | 0.80 | -0.16 | -0.114 | 0.914 | 0.70 | 0.01 | 1.00 | 0.006 | 200 |
| 2013 | 0.50 | 0.80 | 0.40 | 0.80 | -0.16 | -0.114 | 0.914 | 0.70 | 0.05 | 1.00 | 0.032 | 200 |
| 2014 | 0.50 | 0.80 | 0.40 | 0.80 | -0.16 | -0.114 | 0.914 | 0.70 | 0.12 | 1.00 | 0.077 | 200 |
| 2015 | 0.50 | 0.80 | 0.40 | 0.80 | -0.16 | -0.114 | 0.914 | 0.70 | 0.25 | 1.00 | 0.160 | 200 |
| 2016 | 0.50 | 0.80 | 0.40 | 0.80 | -0.16 | -0.114 | 0.914 | 0.70 | 0.40 | 0.95 | 0.243 | 200 |
| 2017 | 0.50 | 0.80 | 0.40 | 0.80 | -0.16 | -0.114 | 0.914 | 0.70 | 0.50 | 0.90 | 0.288 | 200 |
| 2018 | 0.50 | 0.80 | 0.40 | 0.80 | -0.16 | -0.114 | 0.914 | 0.70 | 0.50 | 0.85 | 0.272 | 200 |

| A | N | O | P | Q | R | S | T | U | V | W | X | Y |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR T | Prop dec in price Zt | Quantity (base qty) Qo | Changes in Consumer Surplus dCS | Change in Producer Surplus dPS | Change in Total Econ Surplus dTS | Research Cost US$ 1USD=50PhP | Regulatory Costs US$ | Research + Regulatory Costs US$ | Net Benefit | Net Present Value 5% NPV | Net Present Value 3% NPV | Internal Rate of Return IRR |
| | L*B/(B+C) | *known* | M*N*O[(1+0.5*N*C* | O(L-N)(1+.5*N* | L*M*O(1+.5*N*C | *known* | | | R-U | NPV(r,Ben) | NPV(r,Ben) | IRR(Ben,r) |
| 2004 | - | 182,750 | - | - | - | 100,000 | - | 100,000 | (100,000) | **20,466,196** | **26,594,053** | **50.3%** |
| 2005 | - | 182,750 | - | - | - | 100,000 | - | 100,000 | (100,000) | | | |
| 2006 | - | 182,750 | - | - | - | 100,000 | - | 100,000 | (100,000) | | | |
| 2007 | - | 182,750 | - | - | - | 100,000 | - | 100,000 | (100,000) | | | |
| 2008 | - | 182,750 | - | - | - | 80,000 | 90,000 | 170,000 | (170,000) | | | |
| 2009 | - | 182,750 | - | - | - | 60,000 | 90,000 | 150,000 | (150,000) | | | |
| 2010 | - | 182,750 | - | - | - | 40,000 | 100,000 | 140,000 | (140,000) | | | |
| 2011 | - | 182,750 | - | - | - | - | 100,000 | 100,000 | (100,000) | | | |
| 2012 | 0.002 | 182,750 | 90,058 | 144,093 | 234,150 | - | 95,000 | 95,000 | 139,150 | | | |
| 2013 | 0.012 | 182,750 | 452,061 | 723,297 | 1,175,358 | - | - | - | 1,175,358 | | | |
| 2014 | 0.030 | 182,750 | 1,092,387 | 1,747,819 | 2,840,206 | - | - | - | 2,840,206 | | | |
| 2015 | 0.062 | 182,750 | 2,304,596 | 3,687,354 | 5,991,951 | - | - | - | 5,991,951 | | | |
| 2016 | 0.094 | 182,750 | 3,546,748 | 5,674,796 | 9,221,544 | - | - | - | 9,221,544 | | | |
| 2017 | 0.111 | 182,750 | 4,228,000 | 6,764,800 | 10,992,800 | - | - | - | 10,992,800 | | | |
| 2018 | 0.105 | 182,750 | 3,983,699 | 6,373,919 | 10,357,618 | - | - | - | 10,357,618 | | | |
| | | | ***ΔCS*** | ***ΔPS*** | ***ΔTS*** | **Res Cost** | **Reg Costs** | **Total Costs** | **Net Benefit** | **NPV 5%** | **NPV 3%** | **IRR** |
| | | | 15,697,549 | 25,116,078 | 40,813,627 | 580,000 | 475,000 | 1,055,000 | 39,758,627 | 20,466,196 | 26,594,053 | 50.3% |

## Appendix C: Interview Questionnaire

Interview Questions

1. Are these the regulatory steps as you know them to be? If not, what is missing or what needs to be removed from this list? How long, generally, does each of these steps take to complete? Approximately how much does it cost to complete each step? (answer in boxes below, cross out any non-applicable steps)

| Cost (k$)[1] | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | … | order |
| Project Proposal | | | | | | | | | | | | |
| IBC assess risk-benefit | | | | | | | | | | | | |
| IBC submit to NCBP | | | | | | | | | | | | |
| NCBP proposal review | | | | | | | | | | | | |
| NCBP STRP eval. | | | | | | | | | | | | |
| NCBP biosafety certification | | | | | | | | | | | | |
| Contained Use field trial | | | | | | | | | | | | |
| Ltd Field Trial | | | | | | | | | | | | |
| Multi-location field trial | | | | | | | | | | | | |
| STRP review | | | | | | | | | | | | |
| Gene flow tests | | | | | | | | | | | | |
| Toxicity tests | | | | | | | | | | | | |
| PR communications | | | | | | | | | | | | |

2. The containment step has 4 levels of risk, BL1, BL2, BL3, and BL4. Who decides which level is appropriate for any one organism?

    a. In your opinion, are these risk levels generally applied correctly, overestimated, or underestimated?

    b. Does the cost of containment vary among risk levels?

    c. If so, by how much?

d. Does a higher risk level equate to a longer containment period?

e. If so, by how long?

3. Which agency(s) handle and/or monitor each of the above regulatory steps? If there are multiple agencies, do they have a single overseer? If there are multiple agencies involved in any particular step, does this delay the amount of time to completion of that step? If so, by how much time do you think the existence of multiple agencies delays the completion of that step?

| | Agency(s) | Overseer? | Delay y/n | Time? | Other |
|---|---|---|---|---|---|
| Project Proposal | | | | | |
| IBC assess risk-benefit | | | | | |
| IBC submit to NCBP | | | | | |
| NCBP proposal review | | | | | |
| NCBP STRP eval. | | | | | |
| NCBP biosafety certification | | | | | |
| Contained Use field trial | | | | | |
| Ltd Field Trial | | | | | |
| Multi-location field trial | | | | | |
| STRP review | | | | | |
| Gene flow tests | | | | | |
| Toxicity tests | | | | | |
| PR communications | | | | | |

4. Do(es) the regulatory body(s) differ by product end-use type? (for example human consumption products, animal consumption products and non-consumption products) Do the regulatory steps listed above differ by product end-use type? If so, how so? Does the product type change the costs of each of the regulatory steps? Does the amount of time to complete each of the above steps change with differences in end use?

| **Human Consumption** | | | | | |
|---|---|---|---|---|---|
| | Regulatory Body | Regulatory step change? | How/Why? | Costs | Time |

| | | | | | |
|---|---|---|---|---|---|
| Project Proposal | | | | | |
| IBC assess risk-benefit | | | | | |
| IBC submit to NCBP | | | | | |
| NCBP proposal review | | | | | |
| NCBP STRP eval. | | | | | |
| NCBP biosafety certification | | | | | |
| Contained Use field trial | | | | | |
| Ltd Field Trial | | | | | |
| Multi-location field trial | | | | | |
| STRP review | | | | | |
| Gene flow tests | | | | | |
| Toxicity tests | | | | | |
| PR communications | | | | | |

| **Animal Consumption** | | | | | |
|---|---|---|---|---|---|
| | Regulatory Body | Regulatory step change? | How/Why? | Costs | Time |
| Project Proposal | | | | | |
| IBC assess risk-benefit | | | | | |
| IBC submit to NCBP | | | | | |
| NCBP proposal review | | | | | |
| NCBP STRP eval. | | | | | |
| NCBP biosafety certification | | | | | |
| Contained Use field trial | | | | | |
| Ltd Field Trial | | | | | |
| Multi-location field trial | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| STRP review | | | | | |
| Gene flow tests | | | | | |
| Toxicity tests | | | | | |
| PR communications | | | | | |

| **Non-Consumption** | | | | | |
|---|---|---|---|---|---|
| | Regulatory Body | Regulatory step change? | How/Why? | Costs | Time |
| Project Proposal | | | | | |
| IBC assess risk-benefit | | | | | |
| IBC submit to NCBP | | | | | |
| NCBP proposal review | | | | | |
| NCBP STRP eval. | | | | | |
| NCBP biosafety certification | | | | | |
| Contained Use field trial | | | | | |
| Ltd Field Trial | | | | | |
| Multi-location field trial | | | | | |
| STRP review | | | | | |
| Gene flow tests | | | | | |
| Toxicity tests | | | | | |
| PR communications | | | | | |

5. Do regulations change such as the addition of a regulatory step?

    a. If so, how often?

    b. Does this create problems if they change while a product is in the process of being tested?

c. Would one have to restart the testing phase or back backwards in the steps if the regulation changed while a product was in the process of being tested?

6. Do you believe any of the current steps of the regulatory process are extraneous?

    a. If so, which step(s) and why?

    b. How much time do(es) it/they add to the process?

    c. By how much does that or those steps change the cost of completing the process?

7. Are tests from other countries accepted? If so, under what conditions would they be accepted? From which countries are they most often accepted? Does the acceptance reciprocate with the Philippines? Does this enable the researcher to complete the process more quickly? If tests from other countries are accepted, which step(s), if any, can be skipped? Assuming this reduces the time to completion and the costs, how much time is saved and how much of the cost is reduced?

| **Non-Consumption** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Other country test accepted | Conditions | Which countries | Reciprocation | Time to complete | Skip step? | Time saved | Cost reduction |
| Project Proposal | | | | | | | | |
| IBC assess risk-benefit | | | | | | | | |
| IBC submit to NCBP | | | | | | | | |
| NCBP proposal review | | | | | | | | |
| NCBP STRP eval. | | | | | | | | |
| NCBP biosafety certification | | | | | | | | |
| Contained Use field trial | | | | | | | | |
| Ltd Field Trial | | | | | | | | |
| Multi-location field trial | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| STRP review | | | | | | | | |
| Gene flow tests | | | | | | | | |
| Toxicity tests | | | | | | | | |
| PR communications | | | | | | | | |

8. Are there any countries from which testing would not be accepted?

    a. If so, which countries would those be?

    b. Can any of their previously gained information be used toward completing the process?

    c. If so, does this allow any of the above listed steps to be skipped?

    d. Which ones?

    e. How much time and money would this save?

9. If there is a similar product already on the market, having already completed the regulatory process, can information gained from its testing be used to expedite the process for a product in process of being tested?

    a. Would any of those completed tests be applicable to the currently tested product, allowing it to skip a step or multiple steps?

    b. Which steps could be skipped?

    c. How much time and money would this save, if any?

10. Does the existence of any of the above steps create the need for a larger research staff than if it/they did not exist? Does it increase the need for lawyers or other professionals? On the R&D side, are there any specialists whose job is to assist in moving the product through the regulatory process? Does this increase the cost of bringing the product to market? If so, by how much? Is there any special training required for researchers to be able to participate in any of the above steps of the regulatory process? Does this increase the time it takes to make it to market or the cost of getting a product to market? By how long or how much?

| **Non-Consumption** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Increased research staff | Lawyers | Specialists | Cost increase | How much | Training | Time | How much |
| Project Proposal | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| IBC assess risk-benefit | | | | | | | | |
| IBC submit to NCBP | | | | | | | | |
| NCBP proposal review | | | | | | | | |
| NCBP STRP eval. | | | | | | | | |
| NCBP biosafety certification | | | | | | | | |
| Contained Use field trial | | | | | | | | |
| Ltd Field Trial | | | | | | | | |
| Multi-location field trial | | | | | | | | |
| STRP review | | | | | | | | |
| Gene flow tests | | | | | | | | |
| Toxicity tests | | | | | | | | |
| PR communications | | | | | | | | |

11. Of the above listed steps, can a product fail one or multiple steps and be able to continue through the process regardless of that failure?

    a. Does this change the costs of that step?

    b. By how much? If it did fail a test, what are the possible options from that point (i.e. would researchers have to test again, or would it have to start the process over again, or would the product being tested be dropped entirely, etc)

12. Are there any specific types of GMOs that are able to more easily complete the regulatory process?

    a. If so what are they and why is it easier for these products?

    b. Are they skipping any of the above listed steps?

    c. If so, which ones?

    d. Quantitatively, how does this affect the costs of completion?

13. Is there an advantage to being in a particular sector for completing the process? For example Private, public, or some combination thereof.

    a. If so, what makes it easier to go through the process for that sector?

    b. Do the costs of each of the above steps vary by sector?

c. If so, why and by how much? Does the time required for each step differ by sector? If so, why and by how much?

| Public | | | |
|---|---|---|---|
| | Costs | Time to complete | Why differ in costs or time |
| Project Proposal | | | |
| IBC assess risk-benefit | | | |
| IBC submit to NCBP | | | |
| NCBP proposal review | | | |
| NCBP STRP eval. | | | |
| NCBP biosafety certification | | | |
| Contained Use field trial | | | |
| Ltd Field Trial | | | |
| Multi-location field trial | | | |
| STRP review | | | |
| Gene flow tests | | | |
| Toxicity tests | | | |
| PR communications | | | |

| Private | | | |
|---|---|---|---|
| | Costs | Time to complete | Why differ in costs or time |
| Project Proposal | | | |
| IBC assess risk-benefit | | | |
| IBC submit to NCBP | | | |
| NCBP proposal review | | | |
| NCBP STRP eval. | | | |
| NCBP biosafety certification | | | |
| Contained Use field trial | | | |

| | | | |
|---|---|---|---|
| Ltd Field Trial | | | |
| Multi-location field trial | | | |
| STRP review | | | |
| Gene flow tests | | | |
| Toxicity tests | | | |
| PR communications | | | |

| **Mixed** | | | |
|---|---|---|---|
| | Costs | Time to complete | Why differ in costs or time |
| Project Proposal | | | |
| IBC assess risk-benefit | | | |
| IBC submit to NCBP | | | |
| NCBP proposal review | | | |
| NCBP STRP eval. | | | |
| NCBP biosafety certification | | | |
| Contained Use field trial | | | |
| Ltd Field Trial | | | |
| Multi-location field trial | | | |
| STRP review | | | |
| Gene flow tests | | | |
| Toxicity tests | | | |
| PR communications | | | |

14. Do the above steps vary by intended use such as domestic consumption or intended for export? How so? How does this change the time to completion? How does this change the costs, specific to each step?

| **Domestic Consumption** | | | |
|---|---|---|---|
| | Costs | Time to complete | Why differ in costs or time |
| Project Proposal | | | |
| IBC assess risk-benefit | | | |
| IBC submit to | | | |

| | | | |
|---|---|---|---|
| NCBP | | | |
| NCBP proposal review | | | |
| NCBP STRP eval. | | | |
| NCBP biosafety certification | | | |
| Contained Use field trial | | | |
| Ltd Field Trial | | | |
| Multi-location field trial | | | |
| STRP review | | | |
| Gene flow tests | | | |
| Toxicity tests | | | |
| PR communications | | | |

| **Export** | | | |
|---|---|---|---|
| | Costs | Time to complete | Why differ in costs or time |
| Project Proposal | | | |
| IBC assess risk-benefit | | | |
| IBC submit to NCBP | | | |
| NCBP proposal review | | | |
| NCBP STRP eval. | | | |
| NCBP biosafety certification | | | |
| Contained Use field trial | | | |
| Ltd Field Trial | | | |
| Multi-location field trial | | | |
| STRP review | | | |
| Gene flow tests | | | |
| Toxicity tests | | | |
| PR communications | | | |

15. Have the regulatory steps in the Philippines been focused on products that are typically grown in the Philippines or do they apply to any product?

16. Generally, what, if any, difficulties do researchers face while completing the regulatory process?

    a. Which of the above steps is most difficult to complete?  Why?

    b. Are there intellectual property rights that come with completing the regulatory process?

    c. If so, how does this affect the cost of regulation?

17. Does the cost of the regulatory process require the producers to price seeds so that they are difficult for farmers to afford?

18. Do the costs of the regulatory process prevent companies from undertaking GMO research?

    a. If so, what is typically the point at which a GMO would not be researched or cease to be researched?