Genetically modified (GM) corn in the Philippines : Ecological impacts on agroecosystems, effects on the economic status and farmers' experiences

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Analyzing the farm level economic impact of GM corn in the Philippines

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Abstract

This paper analyses the farm economic viability of GM corn as compared to non-GM corn iso-hybrids in the Philippines. Data was collected from 114 farmers in Isabela province including non-GM, *Bt*, *Bt*HT and HT corn farmers. Results of univariate analysis showed that non-GM corn was not statistically different from GM *Bt*, *Bt*HT and HT corn in terms of production output (PO), net income (NI), production-cost ratio (M) and return on investment (RoI). Multivariate econometric analysis for the agronomic input variables showed a higher RoI at P=0.05 for *Bt* corn as the only difference between seed types. Next, pest occurrence and severity variables were included in the regression to address endogeneity and the Blinder-Oaxaca-decomposition method was used to further investigate differences between growers of *Bt*HT corn and non-GM corn into an endowment and a coefficient effect. The BO analysis showed that *Bt*HT corn has a negative impact on RoI as revealed by the negative signs of the overall mean gap and the characteristics and coefficient components. Contrary to RoI, the overall mean gap indicated that adopting *Bt*HT corn could potentially increase non-GM growers' income mainly from better control of corn borer pest even though mean levels of corn borer occurrence are lower for non-GM growers.

Introduction

The adoption of GM corn, cotton and soybean improves yields and reduces pesticides usage (e.g., Klotz-Ingram *et al.*, 1999; Thirtle *et al.*, 2003; Huesing and English, 2004; Gianessi, 2005). A recent meta-analysis by Finger *et al.*, (2011) of 203 publications on GM corn and cotton provides evidence that these crops lead, on average, to a higher economic performance than conventional crops. Other studies have confirmed these higher averages for specific countries.

In the US for example, the observed overall adoption of glyphosate-resistant crops translated to an annual saving of $1.2 billion for US farmers in 2001 (Gianessi, 2005). Edgerton *et al.* (2012) estimate that *Bt* corn enabled US farmers to harvest an additional 8.4 million ton of corn in 2010, i.e., an additional average yield benefit of 0.51 ± 0.95 t/ha. In addition, there are important non-pecuniary benefits when adopting GM corn such as increased management flexibility and convenience, savings on machinery use, and human health benefits from reduced handling and use of pesticides (Marra and Piggot, 2006; Brookes and Barfoot, 2009).

Similar estimations have been made for developing countries. For the year 2007, the farm income gains in these countries were estimated at $302 and $41 million for *Bt* and HT corn, respectively (Brookes and Barfoot, 2009). The yield increasing effects of GM corn is considered of most importance for developing countries. This is because yield gaps (the difference between farmers' field results and the genetic potential of a crop) tend to be larger in developing countries (Edgerton *et al.,* 2012). Thus, the most obvious pecuniary benefit is increase in yield (Finger *et al.*, 2011; Raney, 2006; Qaim & Zilberman, 2003). In addition there would also be non-pecuniary benefits but no studies have been undertaken to value these for farmers in developing countries (Raney, 2006; Brookes and Barfoot, 2009).

Contrariwise, GM corn and the results reported in studies such as those listed above remain a matter of great controversy. The first issue is with data collection. Yield data for the hybrids might be from breeding programs (field trials) and not from actual production fields. Yield and pesticide usage data from field/farm surveys also has limitations. The main problem with surveys is that neither the early adopters nor the fields chosen for the GM crop are randomly selected leading to a selection bias and this, again, makes a comparison with the non-GM crop problematic (Stone, 2011). Second, studies often provide a partial analysis of yield levels, returns and cost for pest control whereas it is the change in the gross margin which is decisive for farmers' income (Wossink and Denaux, 2006). A further critique is that average figures are misleading and that the performance of GM crops is variable, socio-economically differentiated, and contingent on a range of agronomic and institutional factors (Raney, 2006; Smale *et al.*, 2009; Glover, 2010; Mutuc *et al.*, 2011). There is particularly a need for further evidence on the experience by small, resource-poor farmers. GM crop technology is seen as being capable of benefiting these farmers but this is conditional on institutional settings. For example, the perspective that planting GM seeds would improve the life of poor farmers has been challenged as they have to buy new seeds every season and this makes them dependent on seed suppliers. Finally, many studies build on cross-section data, so that longer term effects have not been analysed (Marvier *et al.*, 2007; Krisna and Qaim, 2012).

Against this background, the present paper evaluates the farm level economic impact of pesticide producing (*Bt*), herbicide tolerant (HT) and stacked gene (*Bt*HT) corn in the Philippines. Asian countries have been slow in the uptake of GM crops that are grown for food and feed and the Philippines is the first and so far only country in Asia to have approved the commercial cultivation of GM corn. After *Bt* corn was first commercialized in the Philippines in 2003, there was a dramatic increase in its adoption. Corn production increased tremendously because yield and farm income levels with *Bt* corn were significantly higher (Yorobe and Quicoy, 2006; Anonymous, 2011). By 2010, GM corn was grown on over a quarter million hectares by 270,000 small-scale, resource-poor Filipino farmers (James, 2010).

In Isabela province, the focus of this paper, yield of *Bt* corn per ha was reported to exceed yield of conventional corn by up to 33% in the 2003-2005 seasons. In 2008-2009, *Bt* and *Bt*HT corn yields surpassed conventional corn by 4-5% and by 13-22%, respectively (Gonzales *et al.,* 2009). Previous studies on the social and economic impact of GM corn in the Philippines (Gonzales *et al.*, 2009; Yorobe and Quicoy, 2006) reported that increased yield and income were the driving factors for the high level of GM corn adoption in the country. Mutuc *et al.* (2011) confirmed the yield enhancing effect of *Bt* corn under poor weather conditions. Yet, a recent study (Afidchao *et al.*, Chapter 6) found striking evidence of negative farmer perceptions with regard to the statement if GM corn could improve their present economic status.

These conflicting findings motivated us to conduct a more in-depth study of the economics of GM corn hybrids in the Philippines. We focus at the farm level rather than at the national level or field level and at the variability across farms/farmers. We take explicitly into account that GM corn seed is substantially higher in price and hard to afford by a resource poor farmer. This price can be up to 84% higher than for non GM-corn depending on the type and number of transgenic traits included in the seed. Thus, to deal with the farm economic issues we seek to know and answer the research question: Is GM corn more economically viable and worth the investment than non-GM corn at the farm level? We investigate farm level differences by corn variety in expenditure for agricultural inputs (labour, seed, and fertilizer costs), gross and net return, production-cost ratio and return on investments. Econometric analyses were done to evaluate if and how agronomic variables (i.e. labour costs, agricultural inputs, corn types and farm area) affect production cost, total return, net income, production-cost ratio and return on investment.

This paper further contributes to the literature by employing the Blinder-Oaxaca decomposition method (Blinder, 1973; Oaxaca, 1973) to decompose the observed differences in economic performance between GM adopters and non-adopters into two components, namely a characteristics effect and a coefficients effect. This decomposition technique is widely used in labour economic applications to study mean outcome differences between groups. For example, the technique is often used to analyse wage gaps by gender or race. More recently it is also used in other areas (Park and Lohr, 2010; Tárrega *et al.*, 2010; Wu *et al.*, 2012). The counterfactual exercise answers the question, what would happen to the GM adopters if their distribution of characteristics was as for the non-GM adopters but if they maintained the returns to their characteristics? A comparison of the counterfactual and estimated performance distribution for the GM group and the non-GM group yields the part of the performance difference that is attributable to differences in covariates (farm and farmer endowments). The remainder of performance difference is then attributable to differences in returns to covariates. To the best of our knowledge, no other study has employed this decomposition technique to investigate the GM-economic impact nexus.

Material and methods

Area description: GM Corn and the family farm in the Philippines

The Philippines has a total of 9.6 million hectares (32%) agricultural land area of which 51% and 44% are arable and permanent croplands, respectively (Anonymous, 2011). There are ~1.8 million corn farmers in the country and 60% of these cultivate yellow corn. Mostly, these farmers are categorized as small, semi-subsistence farmers with a farm area of less than 4 hectares (Gerpacio *et al.*, 2004). All corn in the country is grown on rainfed non-irrigated land. The cornfields of these small farmers are mostly situated in marginal places. In contrast, most of the large-scale plantations of yellow corn are found in well-situated lowland or upland areas.

Small-scale farmers and their families perform the major agricultural activities such as seeding, harvesting and weeding. These households plant one corn variety, sometimes intercropped with tobacco, fruits (pineapple) and vegetables. Post-harvest activities include de-husking, shelling and grain drying which is done manually by both family and hired labour. Harvested corn is sun-dried immediately after harvest (Gerpacio *et al.*, 2004). This is accomplished on drying pavements at home or on the barangay multipurpose pavements but mostly along paved or asphalted national highways and provincial roads notably in the case study region of Cagayan Valley. The small-scale farmers are dependent on trader-financiers for full-season input financing because they lack the necessary capital. Farmer's payback their loans with a certain interest (~7-15%) either in cash or in corn product upon harvest. The trader-financier decides on the terms of condition of the payback agreement. For large-scale farmers that have large cornfields (cornfield size of more than 3 hectares) hired labour and mechanized farming are common practices.

Among the sixteen regions in the Philippines, the Cagayan Valley region ranks first in terms of corn production. Isabela province in the Cagayan Valley region was chosen as the case study area for the farm level economic assessment. In this province, farm demonstrations showcased the advantages of using GM corn including both its pecuniary and non-pecuniary benefits. One of the non-pecuniary benefits of GM corn, especially of *Bt*HT (insecticide plus herbicide tolerant) corn is that less labour inputs are required for weed management. With proper spraying of herbicide, the weed problem can be reduced or totally controlled. Since GM corn seeds cost are higher than the available commercial iso-hybrid corn in the market, high income and large-scale farmers were the first adopters of this technology. More recently small scale and poor farmers have also adopted the technology. However many poor farmers cannot afford to buy herbicides and still resort to manual weeding in *Bt*HT corn employing the labour force of the (extended) family on a cooperative basis.

Survey

The survey was conducted from October to December 2010 to obtain data for the wet growing season. In order to select our respondents within the group of general farmers who were best able to give us the first-hand information we needed, we applied a purposive sampling technique. Purposive sampling was accomplished of 114 corn farmers in the province of which 42, 8, 44 and 20 were non-GM, *Bt*, *Bt*HT and HT corn adopters, respectively (Table 1). Ninety-percent of the respondents were classified as small scale farmers with farm sizes of not more than 3 ha. Only 10% of the respondents were large scale farmers with farm sizes of 4 to 8 ha.

A self-structured questionnaire was used during the face-to-face interview of the respondents who were from 10 municipalities and 33 villages of the province. The questionnaire was structured to obtain information on respondents' farming background and on costs and returns, i.e. labour cost, input cost and other expenses. The labour cost encompasses the labour service fee for man machine day, man animal day and man day entailed during land preparation and cultivation practices (ploughing, harrowing, furrowing, off-barring and hilling-up), chemical application (fertilizer application and spraying of insecticide and herbicide) and pre- and post-harvesting practices (seed planting, harvesting, threshing, hauling and drying) for the 2010 wet growing season. The service fees for man day include both paid labour (hired labour) and non-paid labour (labour by family members). The corresponding wage per farming practice (e.g. harvesting, spraying) employed was calculated by multiplying the number of labourers to the existing standard service fee given per labourer per day (e.g., harvesting cost=10 persons [paid and unpaid labourers] x $4.65 per man day). Input cost covers the payment for the seeds, fertilizers, pesticides and other expenses entailed from land preparation to post harvest.

Prior to employing statistical analyses of the data, the total cost of production (TCP), gross income (GI) or production output (PO), net income (NI), production-cost ratio (M) and return on investment (RoI) were computed in US$ per hectare. Table 2 reports the summation of all the expenses entailed throughout the production to harvest period that was obtained as TCP. The PO refers to the total yield in kg of the 2010 wet season multiplied by the prevailing prize of corn grain per kilogram. The NI was calculated by subtracting TCP from PO. The production-cost ratio (M) was computed as the quotient of the production output and the total cost production per hectare (M=PO/TCP). Finally, the RoI was calculated by subtracting the net income to the product of interest rate paid on loans (IR) and the total cost of production (TCP) i.e. RoI = NI-(IR x TCP).

Univariate and multivariate analysis

A univariate analysis was first employed to evaluate differences on the respondents' information, farming background and production cost and to deal with the single response variables (i.e. corn types, agronomic inputs). A Holm-Bonferroni post hoc test (Quinn and Keough, 2007) was used to assess significant differences of the responses between GM and non-GM adopters.

While the means for production cost, total return, net income, production-cost ratio and return on investment provide the realistic farm economic result of the corn types under farm conditions, a comparison of these means by seed type would be misleading. A correct comparison needs to account for the fact that it is not just (a) the corn type that differs but at the same time (b) many other agronomic inputs and (c) farm characteristics as well. This confounds the impact of seed type on the economic results.

Multivariate analysis was used to evaluate how production output (PO), net income (NI), cost-production ratio (M) and return on investment (RoI) by seed type are directly or indirectly affected by other agronomic input variables. For comparison of the individual response variable between corn types the following conventional production function specification was estimated:

$$y_i = \alpha + \beta_n x_{ni} + \varepsilon_i \quad (1)$$

where y_i denotes the response variables (i.e., the natural logs of PO, NI, M and RoI) in US\$ ha^{-1} of farm i; α is the intercept and x_{ni} is a vector of the natural logs of the explanatory variables 1…, n of farm i, including labour cost in US\$ ha^{-1}, agricultural input cost (fertilizer, seeds or pesticides) in US\$ ha^{-1}, area planted, corn type, and ε_i is the error term with the usual classical properties. The estimated model was formulated following the Cobb-Douglas production function approach of Yorobe and Quicoy (2006) which is linear in the natural logs of the variables.

Starting from the full model for each of the response variable, stepwise regression analyses were performed through gradual elimination of those variables with insignificant p-values. The final model retains the variables with significant p-values. This enables evaluation which agronomic input variables have influence on the response variables tested in this study. The tables present only the results from the final model obtained after the series of stepwise regression analyses. All econometric analyses were performed using R stat. version 2.12.2.

Blinder-Oaxaca decomposition between GM and non-GM corn

The agronomic production function in eqn (1) above covers only part of the heterogeneity among the farmers that is expected to affect their input and output decisions. To proxy farmers' individual production environment a common approach is to include addition variables in the production function. Particularly important in this context is that GM seed and pesticides are applied in response to pest problems. This can give rise to endogeneity of pesticide use decisions and seed type selection and thus inconsistent parameter estimates. Following Mutuc *et al.* (2010) we included a pest occurrence and a severity variable in the production function to eliminate this potential bias.

Next, to the extended equations the Blinder-Oaxaca decomposition technique was applied to further investigate the mean differences in the response variables between GM and non-GM corn farmers. We assumed that GM corn has advantages compared to non-GM corn in terms of the responses because farmers will not shift to GM corn otherwise. Thus we expect that the non-GM corn have a lower mean of responses as compared to GM *Bt*HT corn.

For the decomposition, the extended equation is estimated separately for two groups of farmers (by seed type):

$$\bar{y}_{GM} = \bar{x}_{GM}\hat{\beta}_{GM} + \hat{\alpha}_{GM} \quad \text{for } n_1 \text{ obs} \qquad (2)$$

$$\bar{y}_{nonGM} = \bar{x}_{nonGM}\hat{\beta}_{nonGM} + \hat{\alpha}_{nonGM} \quad \text{for } n_2 \text{ obs} \qquad (3)$$

Recall that residuals sum to zero in eqs (2) and (3). Next, the mean gap in performance between the two groups of parcels, $\bar{y}_{GM} - \bar{y}_{nonGM}$, is split into two parts:

$$\bar{y}_{GM} - \bar{y}_{nonGM} = \underbrace{(\bar{x}_{GM} - \bar{x}_{nonGM})\hat{\beta}_{GM}}_{} + \underbrace{\bar{x}_{nonGM}(\hat{\beta}_{GM} - \hat{\beta}_{nonGM} + \hat{\alpha}_{GM} - \hat{\alpha}_{nonGM})}_{} \quad (4)$$

Mean gap = Characteristics effect + Coefficients effect

where $\bar{x}_{GM}$ and $\bar{x}_{nonGM}$ refer to the means of the explanatory variables, and α and β are the intercept and the coefficient estimates on the explanatory variables for the two samples, respectively. The eqn (4) follows the proposed decomposition formulation of Neumark (1988). Subtracting and adding $\bar{x}_{nonGM}\hat{\beta}_{GM}$ to the right hand side of eqn. (4) and rearrangement gives the decomposition in the characteristics and coefficients effect. An alternative and equally valid formulation in eqn (4) multiplies differences in mean observables characteristics by difference in non-GM coefficient estimates and multiplies differences in coefficient estimates by GM mean observable characteristics.

In eqn (4), the first term of the right-hand side is the part of the performance differential 'explained' by group differences in the predictors, i.e. the part of the gap attributed to differences in observed individual characteristics. The second term is attributable to differences in returns to co-variates, this is the unexplained "coefficient" part. It is important to recognize that this second term includes also all potential effects of differences in unobserved variables. In our case, it is the part of the gap that is due to different returns to the field characteristics and input levels. This second part answers the question if the growers non-GM corn were to switch to GM corn overnight but nothing else observable changed (i.e. the field/farmers' characteristics remained the same) would this lead to better results? A further detailed decomposition examines the percentage contribution of each individual explanatory variable to the total raw differential between the two samples to assess the comparative impact.

A decomposition of the mean gap as discussed above is only useful if the two compared equations are significantly different. Thus, first a Chow test for the difference between eqns. (2) and (3) is required; the null hypothesis is that the parameters of the two equations are equal, meaning that all the independent variables have uniform effects for both subgroups. The formula of the Chow test is:

$$F = \frac{\left(RSS_{pooled} - \sum RSS_j\right) / (k+1)}{\sum RSS_j / (n_1 + n_2 - 2k - 2)} \qquad (5)$$

Chapter 5

where RSS_{pooled} is the residual sum of squares (RSS) in the pooled regression, ΣRSS_j is the sum of the RSS from the two subgroup regressions, k is the number of predictor variables in the model and n_1 and n_2 are the number of observations in the subgroups (Otineno, 2009). The Chow test statistic follows an F-distribution with k+1 and n_1+n_2-2k-2 degrees of freedom.

Results

Respondent's information and farming background

As shown in Table 1, the mean age for the farmers' respondents, of which 25% are female, ranged from 43 to 50. Almost all (94%) of the respondents are married with mean household size of 5-6 members. Respondents have been living in their respective municipality for 35 to 43 years. Most of them reached high school or had a high school diploma or 10th grade. Almost all farmers (98%) in the sample practice mono-cropping. Respondents do not differ significantly in any of these characteristics by corn type.

On Asian Corn Borer (ACB) infestation, respondents vary in responses on the occurrence, concerns on damage and severity of ACB infestations (Table 1). All farmers encountered weed problem but their level of concern varies. Further analyses, revealed large differences between non-GM and *Bt* farmers' responses about: a) concerns on weeds pest and; b) the Asian corn borer (ACB) problem (Table 1). The non-GM respondents were less concerned about weeds pest in their farms than the *Bt* respondents. Likewise, a difference was noted between non-GM and *Bt* farmers' responses about the existence of the Asian corn borer (ACB) problem in their fields. All non-GM respondents confirmed that they have encountered the ACB problem whilst only part of the *Bt* farmers did encounter the ACB problem in their fields.

GM vs. non-GM corn: Production Cost

The total cost of production (TPC) was obtained by summing up the overall cost entailed by farmers per corn type in one hectare corn production (Table 2). This includes all cost components (labour and agricultural inputs) entailed from pre-harvesting to post harvesting activities. Table 2 showed that non-GM corn had significantly lower mean total cost of production than the total cost of production incurred when using GM corn hybrids.

Univariate analyses showed that the total input cost differed between GM and non-GM corn (Table 2). Agricultural input cost between GM corn types, i.e. *Bt* vs. *Bt*HT vs. HT, did not differ but all these GM corn types differed from non-GM corn. This corresponds to the big difference in seed cost between GM and non-GM corn. Seed prize of non-GM corn was statistically lower than GM corn. Seeds costs of all the GM corn types were more than 60% higher than non-GM corn. The cost incurred by non-GM farmers for pesticide use was statistically similar to that by GM farmers (Table 2.2). Total labour cost per hectare of production showed no difference between corn types.

Table 1. Respondents' information and farming background. Similar superscript letters represent no differences between corn varieties at P<0.05 after post-hoc analysis using Bonferroni test

Respondents' information	non-GM (n=42)			*Bt* (n=8)			*Bt*HT (n=44)			HT (n=20)			F	Sig
	Mean	±	sd	Mean	±	sd	Mean	±	sd	Mean	±	sd		
Age	49.29	±	8.97	43.38	±	8.90	46.84	±	12.49	49.50	±	12.34	0.939	0.424^{ns}
Household size	6.43	±	3.12	5.00	±	0.54	5.70	±	2.46	6.30	±	2.64	0.980	0.405^{ns}
Years residing in the area	41.95	±	16.88	34.63	±	18.10	41.00	±	15.89	43.35	±	16.91	0.560	0.643^{ns}
Highest educational attainment[1]	3.93	±	1.96	4.75	±	1.91	4.00	±	1.95	4.70	±	2.20	1.040	0.378^{ns}
Cornfield information					±			±			±			
Area of farm devoted to the new variety[2]	1.33	±	1.36	1.56	±	0.82	2.06	±	1.43	1.85	±	1.44	2.104	0.104^{ns}
Weeds problem[3]	0.71	±	0.46	0.75	±	0.46	0.59	±	0.50	0.60	±	0.50	0.657	0.580^{ns}
Concerns on weeds pest[4]	2.61^{a}	±	0.67	3.50^{b}	±	0.93	2.91^{ab}	±	0.94	2.95^{ab}	±	0.97	2.794	0.044*
Asian corn borer (ACB) problem[3]	1.00^{a}	±	0.00	0.71^{b}	±	0.49	0.82^{ab}	±	0.39	0.89^{ab}	±	0.32	3.431	0.020*
Concerns on ACB pest[4]	3.12	±	0.83	2.75	±	1.39	3.07	±	0.77	2.95	±	0.83	0.517	0.671^{ns}
Severity of ACB damage[5]	3.72	±	1.02	3.13	±	1.55	3.42	±	1.03	3.40	±	1.23	0.968	0.411^{ns}

[1]Scale: 1-No schooling; 2- Elementary level; 3- Elementary graduate; 4- High School Level; 5-High School graduate;
[2]Scale: in hectare
[3]Scale: Yes-1, No-0
[4]Scale: 5- Highly concern; 4- moderately concern; 3- concern; 2-unconcern; 1- Highly unconcern
[5]Scale: 5- Highly severe; 4- severe; 3- moderately severe; 2- negligible; 1- Highly negligible

Table 2. Cost of production (labour, agricultural inputs, other expenses. Values are in US$ per ha at 1US$:42.50 Philippine pesos). Similar superscript letters represent no differences between corn varieties at P<0.05 after post-hoc analysis using Bonferroni test. P values: *** = p<0.001, ** = p<0.01, * = <0.05, (*) = <0.10)

Production cost	non-GM (n=42)			*Bt* (n=8)			*Bt*HT (n=44)			HT (n=20)			F-value	p-value
	Mean		sd	Mean		sd	Mean		sd	Mean		sd		
Total Production Cost	504.70^{b}	±	138.68	669.92^{a}	±	70.67	633.39^{a}	±	110.94	603.12^{a}	±	115.95	9.982	0.000***
1.Total labour cost	***208.60***	***±***	***52.12***	***231.90***	***±***	***61.90***	***228.36***	***±***	***47.58***	***220.17***	***±***	***39.61***	***1.336***	***0.267***^{ns}
Ploughing	42.13	±	20.91	38.09	±	13.69	36.47	±	16.82	37.41	±	14.44	0.776	0.510^{ns}
Harrowing	8.64	±	7.44	7.53	±	11.77	9.85	±	10.58	10.91	±	11.96	0.362	0.780^{ns}
Furrowing	1.34	±	6.84	2.94	±	8.32	1.30	±	3.48	1.59	±	4.04	0.220	0.882^{ns}
Second harrowing	1.01	±	6.54	2.94	±	8.32	1.12	±	3.64	0.00			0.664	0.576^{ns}
Basal application	4.91	±	4.98	9.03	±	4.93	5.50	±	4.44	7.34	±	6.52	2.165	0. 096(*)
Side dress	5.90	±	4.96	6.62	±	3.44	7.85	±	5.29	6.55	±	6.01	1.025	0.385^{ns}
Planting	25.04	±	10.37	24.82	±	7.41	29.39	±	10.06	28.05	±	15.14	1.264	0.291^{ns}
Off-baring	8.10	±	7.97	8.59	±	9.55	5.88	±	8.46	3.79	±	7.84	1.496	0.220^{ns}
Hilling-up	3.03	±	5.89	4.12	±	8.03	2.98	±	6.71	1.76	±	4.51	0.336	0.799^{ns}
Total spraying	8.49	±	9.18	8.65	±	7.48	8.94	±	7.72	5.89	±	4.31	0.736	0.533^{ns}
Insecticide Spraying	2.87	±	3.97	2.35	±	4.53	2.86	±	4.93	1.06	±	2.70	0.990	0.400^{ns}
Herbicide spraying	5.17	±	6.85	6.29	±	6.00	5.60	±	5.76	4.84	±	4.70	0.150	0.929^{ns}
Fungicide Spraying	0.45	±	1.82	0.00			0.48	±	2.25	0.00			0.478	0.698^{ns}
Harvesting	30.84	±	8.67	37.06	±	14.38	33.88	±	6.98	36.29	±	10.60	2.344	0.077(*)
Thresher	35.30	±	13.65	39.58	±	16.52	39.84	±	13.96	42.49	±	16.16	1.338	0.266^{ns}
Hauling	14.23	±	9.94	18.85	±	7.67	19.46	±	12.86	17.11	±	7.76	1.770	0.157^{ns}
Drying	18.84	±	10.36	20.32	±	10.41	22.79	±	10.57	19.48	±	8.92	1.177	0.322^{ns}
2.Total input cost	***262.84***^{b}	***±***	***106.92***	***393.68***^{a}	***±***	***79.84***	***369.10***^{a}	***±***	***88.46***	***354.51***^{a}	***±***	***88.08***	***11.071***	***0.000****
Seed costs	90.01^{b}	±	32.46	152.35^{a}	±	33.55	163.71^{a}	±	32.11	168.00^{a}	±	26.14	49.120	0.000***
Total Fertilizer	165.44	±	88.71	238.38	±	79.93	198.73	±	81.08	181.86	±	72.57	2.309	0.080(*)
Organic	126.86	±	12.85	157.12	±	29.79	148.13	±	12.70	156.06	±	18.39	0.821	0.485^{ns}
Inorganic	36.59	±	85.09	81.26	±	68.39	50.60	±	77.41	34.89	±	79.07	0.886	0.451^{ns}
Pesticides	7.39	±	8.57	2.94	±	8.32	6.67	±	11.73	4.65	±	8.71	0.678	0.567^{ns}
3.Others expenses	***33.26***	***±***	***51.79***	***44.35***	***±***	***26.27***	***35.93***	***±***	***27.10***	***28.45***	***±***	***26.58***	***0.380***	***0.768***^{ns}

GM vs. non-GM: Production and Income

The *Bt*HT and HT corns exhibited the highest gross income or production output (PO) as compared to *Bt* and non-GM corn hybrids (Table 3). *Bt*HT and HT corn out yielded non-GM corn by 8% and 7% but non-GM corn out yielded *Bt* corn by 1%. However, there was no statistical difference in PO between GM and non-GM corn.

The computed net income (NI) showed that *Bt*HT exhibited the highest NI followed in descending order by HT, non-GM and *Bt* corn hybrids (Table 3). *Bt*HT and HT corn net income were higher than non-GM corn by 7% and 5%, respectively. The NI of non-GM corn was higher to *Bt* corn by 15%. However, statistics shows that NI was not different between corn types.

The net-cost ratio (M) was computed by corn type. The lowest net-cost ratio was observed for *Bt* corn; yet, this did not differ statistically from other GM corn types and was found to be not significantly different from non-GM corn (Table 3). Finally, we measured the performance of each corn types under study in terms of return on investment (RoI). *Bt*, *Bt*HT and HTcorn had, respectively, 28%, 10% and 6% higher RoI than non-GM corn (Table 3). Yet, the efficiency as reflected from the computed RoI of non-GM corn was found to be statistically not different to the GM corn hybrids.

Table 3. Production output, net income, production-cost ratio and return on investment between corn types categories using univariate analysis. (Values are in US$ per ha at 1US$:42.50 Philippine pesos).

	non-GM (n=42)			*Bt* (n=8)			*Bt*HT (n=44)			HT (n=20)			F-value	p-value
	Mean	±	sd	Mean	±	sd	Mean	±	sd	Mean	±	sd		
PO	1,103.98	±	539.36	1,071.84	±	455.98	1,299.17	±	372.12	1,272.12	±	442.09	1.671	0.177^{ns}
NI	612.28	±	489.98	436.12	±	456.77	687.54	±	345.17	684.21	±	410.63	0.940	0.424^{ns}
M	2.28	±	1.01	1.698	±	0.70	2.158	±	0.59	2.208	±	0.71	1.231	0.302^{ns}
RoI	503.23	±	341.66	885.64	±	676.05	618.39	±	417.93	572.16	±	424.53	2.046	0.112^{ns}

PO=Production Output
NI=Net Income
M=Production-cost ratio
RoI=Return on Investment

Multivariate analysis

We applied production function analysis to PO, NI, M and RoI. Before the analysis, we first evaluated the residual plots (residual vs. fitted, normal Q-Q, scale-location and residual vs. leverage) for its normal distribution. Data that were non-normally distributed were ln(x+1) transformed. Data presented here are results of the minimal model per response variable obtained after series of stepwise regression analyses.

In explaining the variation in PO, costs of threshing, harvesting and plowing were found to have the largest effect. Among input cost, differences in seed cost seems to be important as expected from the summary statistics in Table 2. The R^2 value was estimated 0.53 for the final model used (Table 4 column A).

Table 4 (column B) shows the multi-agronomic variables that are affecting NI. Area planted and fungicide spraying had the highest impact on NI. The R^2 estimate values are 0.39 for the final model.

On M, variables such as area, fertilizer and labour costs for thresher showed great influence (Table 4 column C). The R^2 estimate values are 0.39 for the final model.

This analysis showed that *Bt* corn had a significantly higher RoI than non-GM corn (Table 4 column D), although the overall effect of corn type was not significant (table 3) whilst none of the other tested agronomic variables did have an effect (R^2: 0.05).

Blinder-Oaxaca decomposition

Next the regression equations as above were extended with a pest occurrence and a severity variable to eliminate potential endogeneity bias. The equations for two response variables (i.e. RoI and NI) and *Bt*HT and non-GM corn were selected for the BO analysis on the basis of the results obtained after subjecting the extended regression models for all the response variables to a Chow test as shown in Table 6.

For the decomposition, the RoI and NI equations are estimated separately as discussed above. The regression results for return on investment (Table 7, column 4 and 5) show that among the assessed variables, corn borer occurrence and costs of labour, seeds and pesticides manifested significant negative effects on GM corn. It is interesting to note that together with farm size and fertilizer, corn borer severity showed positive effects on GM corn's RoI. For non-GM corn, the costs of seeds and pesticide have significant positive effects. All other variables including corn borer occurrence and severity show significant negative effects on non-GM corn's RoI.

The estimated models were then used to split the observed gap between corn types in two portions (Tables 7, last three columns). The sum in the bottom row of Table 7 shows that of the overall raw gap of -3.397 for RoI only 21% (-0.705) can be explained by differences in characteristics of the two samples. The remaining 79% (-2.692) can be attributed to the coefficient or unexplained effect. Notice that the gap is negative and thus the switch to GM corn would mean a drop in RoI for the farmers on average. The last two columns of Table 7 present the contribution of each explanatory variable to the explained and the unexplained component, respectively. In terms of the explained part, most important contributions to explaining the negative gap come from the seed cost (147%) followed by some distance by labour costs (20%). Notice that all the other characteristics reduce the gap (negative percentages).

For NI, the regression results in Table 8 show that among the assessed variables, seed cost, fertilizer cost and corn borer severity carry negative signs. These are variables which manifest negative effects on NI. Farm size, labour cost and pesticide cost have positive signs hence, exhibit significant positive effects on NI for both corn types. Further analysis shows that the two main parts of the mean gap (1.144) have opposite signs; we find a small negative characteristics effect (-23%) and a large positive coefficient effects (123%). In particular, among the explanatory variables of the negative characteristic components, seed cost has the largest percentage (112%) followed by fertilizer cost (61%). Except for farm size and labour cost, the remaining characteristics contribute to increasing the negative gap (positive percentages). Contrary to RoI, the overall gap indicates that adopting GM corn could potentially increase the growers' income. The results in the last two columns of Table 8 show that the mean income advantage from switching to *Bt*HT corn is mainly due to better control of corn borer pest.

Table 4. Estimates of agronomic variables identified to affect PO, NI, M and RoI ha^{-1} employing series stepwise regression analyses. All data was natural log (ln) transformed. P values: *** = p<0.001, ** = p<0.01, * = <0.05, (*) = <0.10); L_i= man labor cost ha^{-1}; I_i= agricultural input cost ha^{-1}; SE = standard error.

	(A) Production Output (PO) [r^2=0.526]	**(B) Net Income (NI) [r^2=0.391]**	**(C) Production-Cost Ratio (M) [r^2=0.386]**	**(D) Return on Investment (RoI) [r^2=0.053]**
	Estimate ± se	Estimate ± se	Estimate ± se	Estimate ± se
Intercept				
Corn types (C_i): Non-GM corn	3.698^{**} ± 0.743	-1181.230 ± 297.630	1.029 ± 0.262	503.190^{***} ± 63.990
Contrast with intercept				
-*Bt* corn	-0.011 ± 0.144	-193.200 ± 133.710	-0.085 ± 0.086	382.560^{*} ± 159.970
-*Bt*HT corn	0.036 ± 0.103	-15.450 ± 77.290	-0.018 ± 0.050	115.220 ± 89.460
-HT corn	-0.002 ± 0.121	-34.550 ± 96.260	-0.037 ± 0.061	69.010 ± 112.660
Covariates				
Plowing cost (L_{1i})	-0.002^{**} ± 0.050			
Furrowing cost (L_{2i})	-0.056^{*} ± 0.047	-92.860^{*} ± 41.630	-0.047^{*} ± 0.026	
Second harrowing cost (L_{3i})	-0.124^{*} ± 0.058			
Insecticide spraying (L_{4i})	0.081^{*} ± 0.031			
Harvesting cost (L_{5i})	0.112^{**} ± 0.118			
Thresher cost (L_{6i})	0.575^{***} ± 0.081	$125.050^{(*)}$ ± 77.030	0.286^{***} ± 0.052	
Side dress cost (L_{7i})		$-66.590^{(*)}$ ± 31.130	-0.048^{*} ± 0.020	
Fungicide spraying (L_{8i})		504.290^{***} ± 82.010		
Seed cost (I_{1i})	0.143* ± 0.125			
Fertilizer cost (I_{2i})			-0.178^{***} ± 0.041	
Area planted (A_{ri})	0.077** ± 0.024	83.940** ± 25.000	0.045** ± 0.016	

Table 5. Correlation values (upper) and p-values (lower) between corn agronomic variables ha^{-1}. (PO= production output/yield; NI = Net income; M= Cost-production ratio; RoI= Return on investment; TPC= Total Production Cost). P values: *** = p<0.001, ** = p<0.01, * = <0.05, (*) = <0.10), ns = not significant

Variables		Pearson's correlation coefficient											
		PO	NI	M	RoI	TPC	Labor cost	Fertilizer cost	Seed cost	Pesticide cost	Area planted	ACB	Weeds
P- values	PO		0.898	0.724	0.096	0.425	0.344	0.237	0.273	0.006	0.300	-0.025	-0.031
	NI	< 2.2e-16***		0.863	0.075	0.160	0.209	0.014	0.138	-0.017	0.287	-0.090	-0.016
	M	< 2.2e-16***	< 2.2e-16***		0.104	-0.014	0.001	-0.116	-0.007	-0.077	0.171	-0.067	-0.060
	RoI	0.309 ns	0.428 ns	0.271 ns		0.079	0.009	0.025	0.157	-0.064	0.000	-0.022	-0.109
	TPC	2.48e-06***	0.090(*)	0.035*	0.401 ns		0.579	0.795	0.506	0.272	0.222	0.129	0.074
	Labor cost	0.000***	0.026*	0.994 ns	0.926 ns	1.5e-11***		0.188	0.073	0.073	0.061	0.026	0.052
	Fertilizer cost	0.011*	0.884 ns	0.002**	0.794 ns	<2.2e-16***	0.045*		0.270	0.076	0.346	0.111	0.084
	Seed cost	0.003**	0.144 ns	0.939 ns	0.095(*)	9.6e-09***	0.441 ns	0.004**		-0.089	0.310	0.224	0.003
	Pesticide cost	0.952 ns	0.857 ns	0.414 ns	0.497 ns	0.324 ns	0.437 ns	0.423 ns	0.086(*)		-0.089	-0.091	0.150
	Area planted	0.001**	0.002**	0.069(*)	0.997 ns	0.018*	0.516 ns	0.065(*)	0.001**	0.349 ns		0.083	0.209
	ACB	0.788 ns	0.341 ns	0.476 ns	0.816 ns	0.172 ns	0.784 ns	0.240 ns	0.016*	0.337 ns	0.378 ns		0.069
	Weeds	0.741	0.868	0.527	0.248	0.431	0.586	0.374	0.973	0.110	0.025	0.468	

Table 6. Chow test outcome for production output, net income, return on investment and cost-production ratio.
P values: ** = p<0.01, ns = not significant

Response variable	df numerator	df denominator	RSS_{BtHT}	$RSS_{non\text{-}GM}$	ΣRSS	F	p-values
Production output	8	70	3.252	9.120	13.210	0.592599	0.955569 ns
Net Income	8	70	21.380	198.940	298.978	3.12391	0.000158**
Return on Investment	8	70	177.493	106.396	358.910	2.31229	0.003652**
Cost-Production Ratio	8	70	50.719	119.100	168.703	0.057502	1.000000 ns

RSS = residual sum of squares in the pooled regression; ΣRSS= sum of the RSS

Table 7. The Blinder-Oaxaca decomposition of the return on investment (ROI) of GM and non-GM corn types.
P values: ** = p<0.01, * = <0.05, (*) = <0.10), ns = not significant

Explanatory Variables	Characteristics		Coefficients		ROI GM evaluated at means	ROI non-GM evaluated at means	Mean Gap	Characteristics Effects (share in %)	Coefficients effects (share in %)
	$\overline{X}_{GM}$	$\overline{X}_{nonGM}$	$\hat{\beta}_{GM}$	$\hat{\beta}_{nonGM}$	$\hat{\beta}_{GM}\overline{X}_{GM}$	$\hat{\beta}_{nonGM}\overline{X}_{nonGM}$		$(\overline{X}_{GM} - \overline{X}_{nonGM})\hat{\beta}_{GM}$	$\overline{X}_{nonGM}(\hat{\beta}_{GM} - \hat{\beta}_{nonGM})$
Intercept	1.000	1.000	11.413	6.806	11.413	6.806	4.607		4.607 (-171%)
Farm size	2.182	1.500	0.042 ns	-0.341 ns	0.091	-0.512	0.602	0.028 (-4%)	0.574 (-21%)
Labor cost	228.341	208.571	-0.007 ns	-0.002 ns	-1.598	-0.417	-1.181	-0.138 (20%)	-1.043 (39%)
Seed cost	163.818	90.024	-0.014 ns	0.033**	-2.293	2.971	-5.264	-1.033 (147%)	-4.231 (157%)
Fertilizer cost	198.750	165.405	0.004 ns	-0.007(*)	0.795	-1.158	1.953	0.133 (-19%)	1.819 (-68%)
Pesticides	6.727	7.429	-0.287 ns	0.318 ns	-1.931	2.362	-4.293	0.201 (-29%)	-4.495 (167%)
Corn borer severity	3.659	3.439	0.127 ns	-0.730*	0.465	-2.510	2.975	0.028 (-4%)	2.947 (-109%)
Corn borer occurrence	1.091	1.119	-2.689(*)	-0.123 ns	-2.934	-0.138	-2.796	0.075 (-11%)	-2.871 (107%)
Sums					**4.007**	**7.405**	**-3.397**	**-0.705 (100%)**	**-1.692 (100%)**

Table 8. The Blinder-Oaxaca decomposition of the Net Income (NI) of GM *Bt*HT and non-GM corn types.
P values: (*) = <0.10), ns = not significant

Explanatory Variables	Characteristics		Coefficients		NI GM evaluated at means	NI non-GM evaluated at means	Mean Gap	Characteristics Effects (share in %)	Coefficients effects (share in %)
	$\overline{X}_{GM}$	$\overline{X}_{nonGM}$	$\hat{\beta}_{GM}$	$\hat{\beta}_{nonGM}$	$\hat{\beta}_{GM}\overline{X}_{GM}$	$\hat{\beta}_{nonGM}\overline{X}_{nonGM}$		$(\overline{X}_{GM}-\overline{X}_{nonGM})\hat{\beta}_{GM}$	$\overline{X}_{nonGM}(\hat{\beta}_{GM}-\hat{\beta}_{nonGM})$
Intercept	1.000	1.000	4.522	5.321	4.522	5.321	-0.799		-0.799 (-57%)
Farm size	2.182	1.500	0.113^{ns}	0.526^{ns}	0.247	0.788	-0.542	0.077 (-29%)	-0.619 (-44%)
Labor cost	228.341	208.571	0.010$^{(*)}$	0.012^{ns}	2.215	2.461	-0.246	0.192 (-73%)	-0.438 (-31%)
Seed cost	163.818	90.024	-0.004^{ns}	-0.001^{ns}	-0.655	-0.108	-0.547	-0.295 (112%)	-0.252 (-18%)
Fertilizer cost	198.750	165.405	-0.005^{ns}	-0.003^{ns}	-0.954	-0.568	-0.386	-0.160 (61%)	-0.226 (-16%)
Pesticides	6.727	7.429	0.074^{ns}	0.013^{ns}	0.495	0.093	0.402	-0.052 (20%)	0.454 (32%)
Corn borer severity	3.659	3.439	-0.014^{ns}	-0.182^{ns}	-0.053	-0.627	0.574	-0.003 (1%)	0.577 (41%)
Corn borer occurrence	1.091	1.119	0.762^{ns}	-1.660^{ns}	0.831	-1.858	2.689	-0.021 (8%)	2.710 (193%)
Sums					**6.648**	**5.504**	**1.144**	**-0.263 (100%)**	**1.407 (100%)**

Discussion

GM corn effect on Cost

One of the most often highlighted reasons for non-GM corn adopters is the high cost of seed per hectare of corn production (Afidchao *et al.*, Chapter 6). This study once again shows that cost of seeds per hectare was far higher for GM corn than for the leading conventional corn hybrids available on the market. This is also one of the main factors influencing the high level of total production cost for GM corn (Tables 2).

Reduction of pesticides usage is one of the benefits that was promised to be achieved when using GM corn (Mutuc*et al.*, 2011; Brookes and Barfoot, 2009; Kleter *et al.*, 2007; Wilson *et al.*, 2005; Huang *et al.*, 2003; Rice, 2003). Yet, our study showed that pesticide cost entailed in all corn types are statistically the same. Our result confirms results reported by Afidchao *et al.* (Chapter 6) where *Bt*HT and HT farmers perceived no reduction in pesticides usage and exposure. This is likewise supported by the findings of Wossink and Denaux (2006) where efficiency of pest control cost between transgenic and conventional cotton found no statistical difference. Finally, the claim that pesticides usage can be reduced was not supported by our study as shown in Table 4. Although, it has been shown in US and Europe that GM corn reduce pesticide and its environmental footprints at 14% reduction rate (Brookes and Barfoot, 2006). Also, a savings of $25-$75/acre due to no insecticide is achieved with *Bt* corn (Rice, 2003). This reduction in pesticide usage observed in US was not manifested at the farm-scale level in Isabela province plausibly due to *Bt* farmers' fear and anticipation of yield loss by pests other than ACB. Hence insecticide spraying is usually done even with *Bt* seed and by HT farmers who opted to have manual weeding due to financial constraints (no money to buy herbicide).

GM corn effect on production, income and return on investment

In terms of yield or production output, our result for conventional and *Bt* corn was similar to the comparisons of yield in 2004-2005 and 2007-2008 in the Philippine provinces of General Santos City and Isabela, respectively where conventional corn was statistically higher than GM corn (Gonzales *et al*., 2009).

*Bt*HT and HT corn produced on average higher yields, *Bt* corn lower than non-GM corn, but these differences were not statistically significant. This shows that GM corn has no straight forward overall advantages compared with non-GM corn. *Bt* corn may produce higher yields (Dilehay *et al.*, 2004; Stanger & Lauer, 2006; Qaim & Zilberman, 2003; Rice, 2003) but other additional points should be taken into account when assessing economic returns. As stated by Dilehay *et al.* (2004) and Stanger & Lauer (2006), *Bt* corn has higher grain moisture, lower test weight and higher harvest & seeds cost; these counterweigh increased yield and might result in adding no benefits when using GM corn. Ma and Subedi (2005) show that on the same maturity, non-*Bt* corn accumulates more nitrogen and leads to highest grain yield. In addition, low to moderate infestation of corn borer provides no advantage in using *Bt* corn. According to

Wolf and Vögeli (2009) using *Bt* corn, an increased yields of up to 15 percent can be obtained when infestation is severe to very severe but at low and moderate infestation conventional maize hybrids are superior when appropriately grade-selected.

The severe to moderately severe ACB infestation in the respondents' cornfields (Table 1) indicate that ACB is still a pest problem in Isabela province. Under high pressure of corn borer infestations, *Bt* corn should have yield advantages. However, in our study the production in GM corn did not exhibit significant yield advantages compared with non-GM corn (Table 3). In the same vein, the reduction of weeds incidence using herbicide tolerant (*Bt*HT and HT) corn varieties (Table 1) did not result in economic advantages compared with non-herbicide tolerant corn varieties (non-GM and *Bt* corn) (Table 3).

In our study, the RoI did not significantly differ among corn types thereby supporting the experimental data of Nolte and Young (2002). Nolte and Young (2002) found no differences between GM herbicide tolerant and conventional corn hybrids in terms of economic return in their 1999 field experiment. Although they have seen significant variations between these corn types in 2000 yet the grain yield effect was stronger than the corn type effect. However, in our study, econometrics showed that RoI could be positively influenced by corn types specifically; *Bt* corn had a significantly higher RoI than non-GM corn (Table 4).

The findings of our study on non-significant difference in mean PO, NI, M and RoI among corn types (Table 3) do not show more profits when using GM corn. In particular, our data did not affirm that *Bt* corn adoption could provide higher yield (Stanger & Lauer, 2006; Dilehay *et al.*, 2004) and higher profits (Qaim & Zilberman, 2003; Rice, 2003). Hence, this does not support the general concept that GM corn provides higher income than non-GM corn. Relatively, our study supplement the data of Baute *et al.* (2002) which refuted the notion that *Bt* corn hybrids in general are higher yielding compared to conventional corn.

Lastly, past studies (Yorobe and Quicoy, 2007 and Gonzales *et al.*, 2009) stated that the farmers that adopted GM corn found it profitable, i.e. the farmers with high risks of ACB, have adopted GM corn by now. Yet, in our present study we found that with moderately severe ACB infestation as observed by the respondents (see Table 1), GM corn did not manifest advantage in terms of profit. This means that further increase of GM corn is no longer profitable, although it might have been in the past.

Agronomic variables effect on PO, NI and M

Several variables could substantially affect PO as shown in Table 4. Labour cost, agricultural input cost and area planted are the influential variables on PO. On labour cost, plowing, harvesting and thresher are noted to greatly affect PO. Among the agricultural inputs, seed cost was shown to have great influence on PO. This may indicate that an increase in PO could require a high input of seeds. Lastly, area planted could as well influence PO. Increasing area planted results to a higher PO and this was supported by the positive and significant correlations of PO.

The relationship between PO and NI was strong and positive as shown in Table 5. Yet econometric shows different inputs have an effect on NI. For NI fungicide spraying is the most important input, followed by the area planted.

The agronomic variables like area, fertilizer and labour costs for furrowing, side dress fertilizer application and thresher are shown to influence M (Table 4). This demonstrates that an increase in area devoted to corn leads to an increase in production cost and production output. On the other hand, fertilizer cost that constitutes around 33 to 44% in the cost production depending on corn types (Gonzales *et al*., 2009), showed a significant negative correlations to M. This directs us to the point that any increase in fertilizer inputs does not warrant higher production (correlation= -0.116; p-value: 0.002, table 5). Lastly, an increase in production or yield also entails an increase in thresher cost with positive significant correlations of 0.589 (p-value= 5.448e-12, table not shown).

Finally, the econometric analysis revealed that among the tested agronomic variables, area planted is the variable that has encompassing positive influence to PO, NI and M. This further mean that any increase in area of corn plantation may contribute to the increase in yield and income as well as production cost.

Blinder-Oaxaca decomposition of return on investment and net income

The RoI and NI as such showed insignificant differences between GM and non-GM corn types and suggest that GM corn does not show superior economic performance compared with non-GM corn (Table 3). Thus, the cultivation of an iso-hybrid non-GM corn seems to have comparable economic results in terms of RoI and NI based on this partial analysis. The application of BO analysis in this study served to check whether other characteristics (such as agricultural input, cost and cornfield pest history) that vary at the same time as seed type could explain some of the difference and thus might confound the overall assessment and determination of which corn type is worth investing. For GM *Bt*HT and non-GM corn growers, the two largest subsamples in this study, the Chow test revealed that there are indeed concomitant differences in the other underlying characteristics (Table 6).

The BO technique served to compare the contribution of independent variables RoI and NI between GM *Bt*HT and non-GM corn through the distinction of an observable characteristics effects and an unexplained coefficient effect. The coefficient component can have a different sign from the characteristics component and this can give insightful information in particular. If both components have the same sign, differences in RoI or NI are as expected. A situation of opposite signs and a substantial coefficient effect is often associated with discrimination in the sociological and labour economics literature in which the Blinder-Oaxaca decomposition is commonly applied.

The last two columns of Table 7 show that for RoI the sums of the two components have identical signs (negative). However for individual variables differences in signs do occur. For both pesticide costs and for corn borer occurrence there is a negative impact on the RoI which is unexpected given the lower average for these variables for the non-GM sample. Finally, the intercept is responsible for most of the coefficients effects indicating the contribution of unobservable characteristics (such as physico-chemical characteristics of cornfields) to the difference in RoI.

In contrast, in case of NI, the sums of the two components shown in the last two columns of Table 8 do not have identical signs. The characteristics effect making up a small portion (23%) of the gap bears a negative sign. This indicates a negative effect on NI by the differences in *Bt*HT and non-GM farmers' observable characteristics which is mainly attributed to seed costs and costs of fertilizer inputs. However this is counteracted by the coefficients or unexplained component which has carry a positive sign and is mainly due to pesticide input, corn borer severity and occurrences. In general, this shows that *Bt*HT has disadvantages on NI based on observable characteristics yet, could provide economic advantage overall due to better pest control even for cornfields less heavily infested with corn borer pest and also due to savings on pesticide costs.

Conclusion

This study focused on small-scale farmers as they constitute the majority of corn farmers and are usually at the bottom in the economic production spectrum. They are likewise the most vulnerable groups easily malleable to be influenced with new introduced technologies that promise superior economic gains. The vast increment and wide-scale cultivation of GM corn in the Philippines is attributed to risk-averse farmers as well as driven by economic benefits offered by these novel varieties. While it is true that past studies showed the adoption of GM corn could increase yield and provide more profits to farmers, our study showed no difference in production output between corn varieties anymore. This study showed that GM corn adoption does no longer directly provide superior economic advantage against non-GM corn considering all the variables studied.

We found that the Blinder-Oaxaca decomposition technique usually used in racial and gender discrimination studies can as well be applied to agriculture economic related studies. Employing this technique allowed us to compare and identify variables with marked influences on the results of our study. Finally, this study can be undertaken on a larger scale to obtain more information on the economic benefits from GM corn technology overtime viz a viz its wide scale adoption in different economic settings and locations.

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