Ex Ante Economic Impact of Genetically Modified (GM) Cowpea in Benin

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Abstract

The net impact of pest-resistant GM crops on the welfare of both producers and consumers in developing countries is currently unknown and subject to speculation. This study uses choice-based conjoint protocol to estimate the net impact of pest-resistant Genetically Modified (GM) cowpea on net social welfare in Benin given price and income risks. Results imply that Bt cowpea will increase expected net social welfare by about $US 50 million per year in Benin given no inefficiencies in the seed sector. If inefficiencies in the seed sector are such that cowpea growers can access Bt cowpea seeds only 50% of the time, net benefits from Bt cowpea drop to about $US 11 million per year.

Introduction

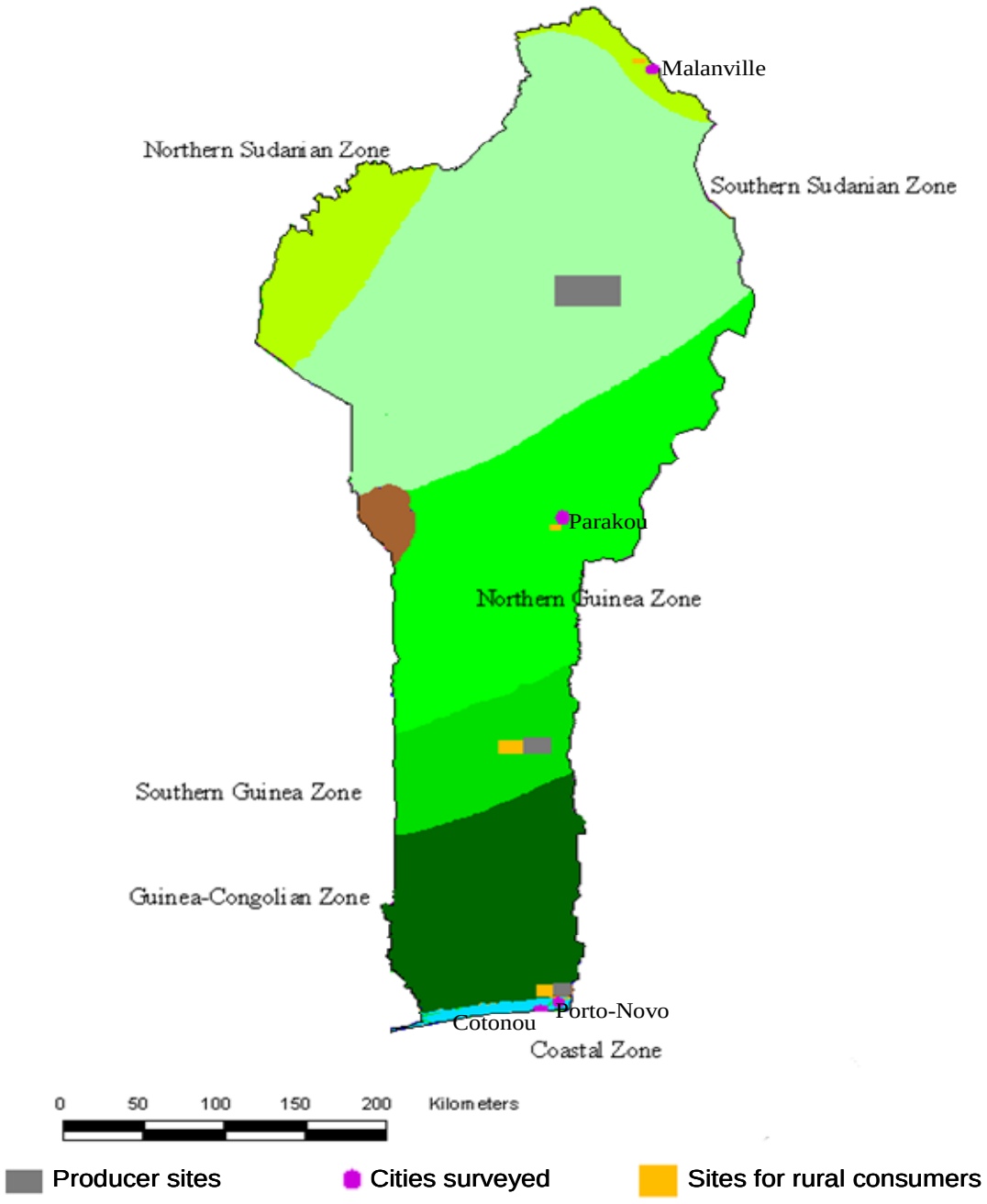
Cowpea is the most economically important indigenous grain legume crop in Africa. They are an important food for farm families, a key cash crop in dry areas, and essential to nutrition of the urban poor in West Africa. Pest-resistant genetically modified (GM) cowpea varieties are a new technology that could increase cowpea yield, thereby increasing the productivity of the land allocated to cowpea production, and hence facilitating, via regional trade and/or self-sufficiency, the process of satisfying the food requirements of the rapidly growing African population. The proposed genetic modification is insertion of DNA from the organism *Bacillus thuringiensis* (Bt) into the genome of traditional cowpea. This genetic modification would allow the cowpea plant to produce Bt toxin within its own cells and to thereby resist attacks by *Maruca vitrata*

without the application of pesticides. Genetically Modified cowpeas have been developed in a laboratory in Australia, but they are not yet available in Africa. The net impact of pest-resistant GM cowpea varieties on the welfare of both producers and consumers in developing countries is currently unknown and subject to speculation. One study of the farm level economic impact of GM seeds in Africa by Thirtle, et al. (*World Development*, 2003) showed that resource-poor farm households in South Africa would benefit from Bt cotton. Consumer reaction to GM food in Africa has also not been well studied. A study by Kushwaha et al. (*AAEA Selected Paper*, 2004) found that Nigerian consumers have serious ethical and health concerns about GM crops. In addition to the lack of accurate information on GM benefits to African populations, GM cowpea cultivars are likely to be introduced in a region characterized by a very weak seed sector. Hence, the goal of this study is to estimate the ex ante socio-economic impact of Bt cowpea in Benin under various scenarios on the economic state of the seed sector. Benin is a coastal country in West Africa, just west of Nigeria. Benin has about 8 million people. Five million live in rural areas. Over 70% of Benin's population lives on less than $2/day. The study' goal is achieved by testing the following hypotheses:

- H1: Assuming no market failures in the seed sector, the adoption of Bt cowpea will increase overall social welfare by at least 15%
- H2: The expected social welfare provided by Bt cowpea will be about 50% of the expected welfare increase estimated in H1 if the seed sector has market failures such that farmers can access Bt cowpea seeds 50% of the time

Survey Design

Data for the study was collected among consumers and cowpea growers in Benin, using Choice-Based Conjoint protocol. 268 consumer families and 112 cowpea growers were surveyed via direct interviews, since most of the population is illiterate. Figure 1 illustrates the regions surveyed for this study. According to Figure 1, the sample of urban consumers in Benin is composed of 136 households selected in the cities of Cotonou, Porto-Novo, Parakou, and Malanville. The sample of rural households is composed of 132 households selected in the Guinea-Congolian, Southern Guinea, Northern Guinea and Northern Sudanian agro-ecological zones. Figure 1 also implies that the sample of cowpea growers was selected in the Guinea-Congolian, Northern Guinea, and Southern Guinea zones. Cowpea growers in these 3 zones account for more than 95% of the cowpea produced in Benin (Aitchedji et al., 2004).



Source: Wezel (1999)

Figure 1: Area surveyed for Study - Benin

Stratified random samples were selected for both producers and consumers. For producers, major cowpea-producing regions were linked with their respective agro-ecological zones. A random sample of 4 villages was then selected in each agro-ecological zone. In each village, an exhaustive list of major cowpea producers was obtained, and this list was divided into sub-lists reflecting categories of farmers sharing similar characteristics in terms of gender, cowpea variety planted, pest infestation control measure, and conservation method for cowpea. A random sample with the same distribution fo categories as the population The proportion of each category of producers was then computed in relation to the population of cowpea growers in the village. Afterwards, a random sample with the same category distribution as the population of cowpea growers was then selected. This sample of 10 farm households was randomly selected among the population of cowpea growers in the village (Aitchedji et al., 2004). For urban consumer households, major markets in the country were identified and linked to their largest surrounding city. Villages for rural consumer households were selected in each Beninese agro-ecological zone. In each selected region, raw cowpea sellers working in open air markets were interviewed on the characteristics of cowpea buyers. Cowpea buyers can fall into one of the following categories: buying cowpea mostly for home consumption; buying cowpea mostly to re-sell it. 40 households were then randomly in each selected rural and urban area in accordance with the interview results with cowpea sellers. If for example, the interview results with raw cowpea sellers implied that the proportion of people buying cowpea mostly for home is around 40% in the region, then the sample of 40 households had to include 8 household buying cowpea mostly for home consumption and 14 household s where cowpea is bought mostly for resale.

Two types of questionnaires (See Appendix A for copy of survey questionnaires) were used for the survey: one questionnaire involving choice experiment only and the other combining cheap talk with choice experiment. Cheap talk consists in explaining hypothetical bias to respondents so as to reduce its occurrence during the market simulation, and hypothetical bias occurs when the simulated market does not seem familiar and believable to respondents. The choice experiment involved a simulation of a market scenario very similar to the one that respondents are exposed to in their transactions involving cowpea. In this experiment, the respondent is invited to imagine that he/she is in front of a seller in a market to buy cowpea. The seller then provides advantages and disadvantages of conventional and Bt cowpea prior to offering these products at given prices to the client. For cowpea growers, the seller also offers insecticide in addition to conventional and Bt cowpea seeds. Buyers are asked to provide "certain quantities", i.e. quantities of Bt and conventional cowpea they are sure to buy regardless of what their future income turns out to be; (Freeman, 1993; Quaim and De Janvry, 2003; Hudson and Jones, 2001; Baidu-Forson et al., 1997; Wheeler and Damania, 2001; Whitehead et al., 1993; Bjornstad et al., 1997; Champ and Bishop, 2001; List and Gallet, 2001; Nape et al., 2003; Lusk, 2003; Brown et al., 2003).

Primary data consist of socio-economic characteristics of the household as well as its WTP for Bt and conventional cowpea. The socio-economic data has two major purposes: estimate and validate the WTP data gathered via the survey, and also identify the major

factors affecting the likelihood of a household adopting Bt cowpea. Secondary data was also collected on the number of urban and rural households in each zone surveyed.

Theoretical Model

The household model is used to capture the problem of the Beninese household. This model implies that the problem of the household is composed of three sub-problems: a worker sub-problem where the household aims at determining the optimal allocation of its time between work and leisure; an income-generating sub-problem where the household aims at defining the optimal allocation of inputs into its family business and other non-family businesses; and a consumption sub-problem where the household aims at determining the optimal levels of consumption goods/services. The income of the urban household comes from two potential sources: family business that involves one or more family members and a non-family business; the former generates monthly incomes that vary depending on market conditions, while the non-family business tends to provide constant income (Sadoulet and de Janvry, 1995). Therefore, the problem of the urban household can be written as follows:

$$\underset{C^o, C^h, R; X, L}{Max} \; E\left(U\left(A\left(C^o, \quad C^h, \quad R\right); z^c, z^p, \varepsilon_u\right)\right) \quad (1)$$

subject to:

$$P^o C^o + P^h C^h + wR \leq P^h \bar{Y} + wE - wL \quad (2)$$

$$\bar{Y} = G\left(X, \varepsilon_p\right) \quad (3)$$

$T \leq \overline{T}$ (4)

Equation 1 implies that the household aims at maximizing the expected utility/satisfaction defined over the attributes $\left(A\left(C^o, \quad C^h, \quad R\right)\right)$ of the consumption goods/services not produced by the household $\left(C^o\right)$, the consumption goods/services produced by the household $\left(C^h\right)$, and leisure $\left(R\right)$; utility is also assumed to be dependent upon the consumption $\left(z^c\right)$ and production $\left(z^p\right)$ characteristics of the household; ε_u is the error term reflecting that portion of utility specific to the household but unknown to the researcher. Equation 2 reflects the budget constraint faced by the household and implies that its expenditures must be lower or equal to its full income. P^o is a vector of prices for the consumption goods/services not produced via the family business; P^h reflects the prices of the consumption goods/services produced by the household; w is the opportunity cost of time; $\tilde{Y}$ is a vector reflecting the random quantities of goods/services produced by the household; E is the amount of time available for work and leisure; and L reflects the amount of labor hours that the household allocates to the family business. Equation 3 reflects the technology involved in the production sub-problem of the household with X reflecting input quantities and ε_w reflecting the random portion of output. Equation 4 reflects constraints on the availability of fixed inputs with T being a vector of fixed inputs and $\overline{T}$ reflecting the maximum amount of fixed inputs available for production.

Assuming non-separability, the problem of the household can be re-written as

$\underset{X,L}{Max}\ E\left(V\left(P^o, P^h, w, \overset{\prec}{Y}, E; z^c, z^p, \varepsilon\right)\right)$ subject to the constraints expressed by equations 3 and 4.

The solution to the problem of the household can be written as

$E\left(V\left(P^o, P^h, w, \overset{\prec}{M}^*\left(\overset{\prec}{Y}^*\left(X^*, L^*, \overline{T}\right), E\right); z^c, z^p, \varepsilon\right)\right)$ where $\overset{\prec}{M}^*$ reflects the distribution of optimal full incomes of the household, and $\overset{\prec}{Y}^*\left(X^*, L^*, \overline{T}\right)$ reflects the distribution of optimal output quantities produced via the family business.

The optimal solution to the problem of the household can be used to estimate the economic impact of a new technology on the welfare of the household given risks, and given the absence of complete and actuarially fair insurance against risks. Bt cowpea, if adopted by the representative household, would have the following impacts:

- Consumer sub-problem: Bt cowpea might change the attribute quantities in the direct utility function of the household; it might also change its preferences; therefore the optimal consumption levels of commodities might change
- Producer sub-problem: Bt cowpea will change the technologies used in the family business if the latter involves cowpea
- Worker sub-problem: given the impact of Bt cowpea on production technologies and its potential impact on consumption preferences, the consumer household might change the time its allocate to both leisure and work

Without Bt cowpea, the expected optimal utility of the cowpea grower is

$\overline{ev}_{noBt} = E\left(V\left(P^{o}_{noBt}, P^{h}_{noBt}, w, \overset{\prec}{M}^{*}_{noBt}; z^{c}_{noBt}, z^{p}_{noBt}, \varepsilon_{noBt}\right)\right)$. With Bt cowpea the expected indirect utility function of the consumer household becomes

$ev_{Bt} = E\left(V\left(P^{o}_{Bt}, P^{h}_{Bt}, w, \overset{\prec}{M}^{*}_{Bt}; z^{c}_{Bt}, z^{p}_{Bt}, \varepsilon_{Bt}\right)\right)$, and the distribution of compensating variations that equalize expected utility with and without Bt cowpea is found with the following equality: $ev_{Bt} = E\left(V\left(P^{o}_{Bt}, P^{h}_{Bt}, w, \left[\overset{\prec}{M}^{*}_{Bt} - \overset{\prec}{CV}\right]; z^{c}_{Bt}, z^{p}_{Bt}, \varepsilon_{Bt}\right)\right)$ where $\overset{\prec}{CV}$ is a vector reflecting the distribution of welfare changes caused by Bt cowpea. The latter distribution of optimal welfare changes can be used to identify the minimum welfare change that Bt cowpea would bring in the future if adopted.

Results

Table 1 presents summary statistics for the consumers and producers interviewed for this study. Table 1 shows that the average household producing cowpea is composed of about 10 people. In this average household, the primary decision-maker for cowpea production uses chemical insecticide for pest control in cowpea. This household is also self-insured against the risks related to cowpea production, in the sense that it buys the same quantity of cowpea seeds regardless of the price and income risks it faces. Moreover, the primary decision-maker for cowpea production in this average household has never heard of Genetically Modified Organisms (GMOs).

Based on table 1, the average urban household is smaller in size compared to the average rural household. In the average urban household, the primary decision-maker for food purchase has received a western-based education, but has never heard of GMOs. In the average rural household, the primary decision-maker for food purchase has also never heard of GMOs, but has also never received western-based schooling. Both urban and rural households buy cowpea mostly to eat at home and prefer white to either brown or red cowpea. The two households also tend not to be self-insured against the price and income risks they face in relation to cowpea. However, the average and lowest monthly incomes seem to be slightly higher in the average urban household compared to the average rural household. Moreover, the occurrence frequency of the lowest monthly income seems slightly higher for the rural household compared to the average urban household.

Table 1: Summary Statistics for Sample Variables – Cowpea growers and consumers

		Cowpea grower			Urban consumer			Rural consumer		
Name	Description	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Qty_Bt	Quantity of purchased Bt cowpea as stated by respondents (kg/month)	12.08	0.00	263.2	382.20	0	32000	179.73	0	8000
Qty_cnl	Quantity of purchased conventional cowpea as stated by respondents (kg/month)	0.90	0.00	21.00	60.04	0	4800	24.66	0	1600
P_Bt	Bt cowpea price ($US/kg)	0.47	0.08	1.11	0.43	0.08	1.26	0.47	0.08	1.26
P_cnl	Price of conventional cowpea ($US/kg)	0.56	0.24	0.83	0.19	0.24	0.94	0.57	0.24	0.94
P_ci	Price of chemical insecticide ($US/litre)	6.47	3.70	9.25	-	-	-	-	-	-
U_PBt	Constant price of Bt cowpea; component of utility of reference ($US/kg)	-	-	-	0.12	0.08	0.18	0.12	0.08	0.18
U_pcnl	Constant price of conventional cowpea; component of utility of reference ($US/kg)	-	-	-	0.35	0.24	0.54	0.35	0.24	0.54
U_EM	Average monthly income; component of utility of reference ($US)	-	-	-	153.36	36.99	554.82	146.32	36.99	507.66
U_lm	Lowest monthly income; component of utility of reference ($US)	-	-	-	90.19	18.49	369.9	87.32	18.49	208.06
Freq_lm	Frequency for lowest income; component of utility of reference	-	-	-	0.34	0.08	0.75	0.38	0.08	1
Ump	Wealth from agriculture; component of utility of reference ($US)	915.11	0.62	6503.20	-	-	-	-	-	-
H_size	Household size (people)	9.90	3	33	6.70	2	20	6.87	2	25
Educ	1 if primary decision-maker for food purchase attended western-based school; 0 otherwise				0.59	0	1	0.23	0	1
White cowpea	1 if household consumes white cowpea; 0 otherwise				0.86	0	1	0.65	0	1
Home	1 if household buys cowpea mostly for home consumption; 0 otherwise				0.68	0	1	0.64	0	1
Know	1 if primary decision-maker in household has heard of GMOs; 0 otherwise	0.05	0	1	0.13	0	1	0	0	0
Ins	1 if household is self-insured against risks; 0 otherwise	0.53	0	1	0.04	0	1	0.06	0	1
Ci	1 if household uses chemical insecticide for pest control in cowpea; 0 otherwise	0.80	0	1	-	-	-	-	-	-
Bi	1 if household uses botanical insecticide for pest control in cowpea; 0 otherwise	0.05	0	1	-	-	-	-	-	-
Sg_z	1 if household is in southern guinea zone; 0 otherwise	0.36	0	1	-	-	-	0.18	0	1
Ng_z	1 if household is in northern guinea zone; 0 otherwise	-	-	-	-	-	-	0.24	0	1
Ss_z	1 if household is in southern sudanian zone; 0 otherwise	0.36	0	1	-	-	-	-	-	-
Ns_z	1 if household is in northern sudanian zone; 0 otherwise	-	-	-	-	-	-	0.24	0	1

Certain Hicksian Cowpea Demand for Cowpea Growers in Benin

Table 2 presents the results from the econometric estimation of demands system for Bt and conventional cowpea seeds by cowpea growers and consumers in Benin. The results in Table 2 are based on SUR econometric models given correction for autocorrelation.

For the estimated certain Hicksian demand function for Bt cowpea seeds by the cowpea grower, the R-square value implies that the econometric linear model seems to explain well the behavior of the quantity demanded of Bt cowpea seeds. The results also imply a negative relationship between the price and quantity demanded of Bt cowpea seeds, which is with producer theory. These results also suggest that knowledge of GMOs and use of botanical insecticide positively influence the demand for Bt cowpea seeds. Self-insurance also increases the amount of Bt cowpea seeds demanded by the household. The results also seem to imply that cowpea growers in the Guinea-Congolian zone (more humid zone) have a higher demand for Bt cowpea compared to the ones in the Northern-Guinea or Southern-Sudanian zones; and the demand for Bt cowpea seems to decrease in intensity from the south to the north; this results seems to confirm the hypothesis implying that Bt cowpea would be more beneficial in regions that are more humid.

For the estimated certain Hicksian demand function for conventional cowpea seeds by the cowpea grower, the R-square value implies that the econometric linear model seems to capture well the relationship between endogenous and explanatory variables. The results in Table 4 imply a positive relationship between the price of chemical insecticide and the

quantity demanded of conventional seeds, so that conventional seeds and chemical insecticide appear to be substitutes; this result seems odd since chemical insecticide is usually used with conventional seeds for cowpea production so that these two products should be complement rather than substitutes; however, the estimated coefficient on the price of chemical insecticide is very small, indicating a very weak substitution between chemical insecticide and conventional cowpea seeds. The results in Table 4 also imply that larger households tend to buy more conventional cowpea seeds; similarly, the cowpea grower that uses botanical insecticide for pest control also tends to buy more seeds. The estimated demand for conventional seeds seems to be highest in the Northern-Guinea zone, and cowpea demand seems higher in the Guinea-Congolian compared to the Southern-Sudanian zone.

Table 2: Estimated Certain Hicksian Demand Functions for Bt and Conventional Cowpea – Cowpea Growers and Consumers in Benin

	Estimated Certain Hicksian demand for cowpea grower		Estimated certain Hicksian demand for urban household		Estimated certain Hicksian demand for rural household	
Variables	Bt cowpea (linear)	Cnl cowpea (linear)	Bt cowpea (linear)	Cnl cowpea (linear)	Bt cowpea (linear)	Cnl cowpea (linear)
Intercept	9.4622* (6.0059)	-1.5034 (1.4088)	-927.90 (761.68)	362.72** (137.23)	-1108.9** (611.13)	-1384.8** (200.96)
P_Bt	-7.5764** (2.0376)	0.22141 (0.37925)	-854.02** (147.28)	89.167** (38.820)	-325.94** (47.410)	16.284** (8.5052)
P_cnl	2.5682 (2.7172)	-0.50639 (0.49215)	-91.732 (136.04)	-162.95** (37.771)	-35.526 (49.032)	-41.395** (8.1896)
P_ci	-0.054237 (0.11720)	0.027837* (0.021546)	-	-	-	-
U_PBt	-	-	4001.8 (5047.1)	-	9262.9** (3794.6)	-
U_pcnl	-	-		-526.25 (762.37)		2898.1** (417.19)
U_EM	-	-	31.474** (3.1752)	-0.49020 (0.68266)	0.39777 (0.53398)	-0.48688** (0.14084)
U_lm	-	-	-19.208** (4.2312)	0.54880 (0.90908)	-506.93** (95.855)	-81.727** (23.307)
Freq_lm	-	-	834.96 (680.88)	-452.58** (141.32)	1.8834** (0.85337)	1.2804** (0.22053)
Ump	0.0013065	-0.00017602	-	-	-	-

	(0.0011020)	(0.00022813)				
H_size	0.20621 (0.28658)	0.19909** (0.058285)	-42.737* (32.016)	3.6308 (7.0972)	12.584** (6.5319)	6.4621 (1.8002)
Educ	-	-	-1351.6** (201.98)	111.64** (42.964)	22.034 (59.569)	-9.5777** (14.616)
White cowpea	-	-	-576.60** (266.83)	43.422 (56.695)	109.50** (63.197)	39.070** (16.323)
Home	-	-	-641.23** (207.52)	-199.93** (43.547)	-341.22** (43.068)	-46.651 (11.410)
Know	37.282** (5.4109)	-2.1225** (0.99933)	-770.32** (354.96)	67.891 (74.047)	-	-
Ins	11.169** (2.6033)	-0.31022 (0.52246)	-587.19 (550.93)	-26.201 (116.89)	-126.94* (86.791)	12.000** (22.470)
Ci	2.1430 (4.0430)	0.92440 (0.83708)	-	-	-	-
Bi	44.501** (6.2298)	6.7930** (1.2558)	-	-	-	-
Sg_z	-13.746** (5.7081)	2.1883* (1.5480)	-	-	593.25** (197.72)	465.84** (66.540)
Ng_z	-	-	-	-	535.15** (258.61)	584.69** (86.331)
Ss_z	-15.131** (5.8423)	-2.5668* (1.6116)	-	-		
Ns_z	-	-	-	-	788.68** (292.85)	628.59** (101.63)
Rho1	0.74685** (0.034223)	-	0.83769** (0.018779)	-	0.59537** (0.024248)	-
Rho2	0.00073513 (0.0066881)	-	0.012017** (0.45381E-02)	-	0.019263** (0.0044272)	-
Rho3	-	-0.055549 (0.16706)	-	0.11109 (0.095919)	-	0.23581** (0.091343)
Rho4	-	0.83744** (0.038546)	-	0.67786** (0.023128)	-	0.81261** (0.018266)
R-square	0.7609	0.6860	0.7894	0.5372	0.5062	0.7620

Numbers in parentheses are standard errors
* and ** represent statistical significance at the 10% and 5% level, respectively

Hicksian Certain Cowpea Demand for Urban Household in Benin

In Table 2, the R-square value, related to the estimated demand for Bt cowpea by the urban household, implies that the econometric model used to estimate this certain demand seems to capture well the relationship between the explanatory and exogenous variables. However, the model used for conventional cowpea, although strong, seems less able to capture the variation in the endogenous variable, the quantity demanded of conventional cowpea by the urban household.

The results in Table 2 for the urban household imply that the price of Bt cowpea seems to negatively impact Bt cowpea and this in turn implies that Bt cowpea is not a Giffen good. These results also seem consistent with economic theory in terms of the relationship between utility and the Hicksian demand. The utility of reference related to the Bt cowpea results in Table 2 for the urban household is function of a reference price for Bt cowpea, the average income of the household, its lowest income and the occurrence frequency of its lowest income. Economic theory suggests that the indirect utility function should increase with income. The results in Table 5 are consistent with economic theory since they imply that imply that the reference utility increases with average income. The results also imply that the quantity demanded of cowpea is lower in the household where the primary decision-maker for food purchase has attended a western-based school system or has heard of GMOs; Bt cowpea demand is also lower in the household where white cowpea is mostly consumed compared to other cowpea varieties or where cowpea is purchased mostly for home consumption compared to resale.

Based on the results in Table 2, the estimated certain demand function for conventional cowpea by the urban household also seems consistent with economic theory. The quantity demanded of conventional cowpea seems negatively impacted by the price of conventional cowpea, which again, seems to imply that conventional cowpea is not a giffen good. The results seem to imply a positive relationship between the quantity demanded of conventional cowpea and Bt cowpea price; therefore, conventional and Bt cowpea seem to be substitutes in the eyes of respondents. The only variable that seems to

statistically impact the utility of reference is the occurrence frequency of the lowest income and the latter seems negatively related to the utility of reference; the higher the probability of getting a low income, the smaller the utility of reference and therefore the smaller the demand for conventional cowpea. This result seems consistent with economic theory, which implies that indirect utility should increase with income. The quantity demanded of conventional cowpea seems higher in the household where the primary decision-maker for food purchase has attended a western-based school system; it also seems lower in the household where cowpea is bought mostly for home consumption

Hicksian Certain Cowpea Demand for Rural Consumer Household in Benin

Table 6 presents results from estimating the system of certain demand functions for Bt and conventional cowpea for rural consumers. For the estimated certain demand for Bt cowpea, R-square value in Table 6 implies that econometric model moderately captures variation in explanatory variable. The results also imply that the quantity demanded of Bt cowpea decreases with an increase in the price of Bt cowpea and this indicates that Bt cowpea is not considered a giffen good by the rural household; it is difficult to estimate the net impact of the utility of reference on the demand for Bt cowpea, since the results in Table 6 imply that the variables affecting this utility of reference seem to have contrary effects; an increase in the reference price of Bt cowpea should decrease the utility of reference while an increase in income should have a contrary effect. Bt cowpea demand seems positively related to household size and this makes intuitive sense; the results also imply that the household where white cowpea is consumed buys more cowpea; the one

where cowpea is mostly used for home consumption buys less cowpea and the one that is self-insured against risks also buys less cowpea compared to the non-insured household.

For the estimated certain demand for conventional cowpea, R-square value implies that econometric model seems to capture quite well the relationship between explanatory and exogenous variables. The results in Table 6 also imply that the demand for conventional cowpea seems negatively related to the price of conventional cowpea and this seems to imply that conventional cowpea is not a giffen good; similarly, the price of Bt cowpea seems to negatively impact the demand for conventional cowpea: such result is consistent with intuition which would suggest that Bt and conventional cowpea are substitutes; however, it is difficult to estimate the net relationship between the reference utility and the demand for conventional cowpea; cowpea demand should be negatively related to the reference utility; the results in Table 6 imply that both the reference price for conventional cowpea and average income seem to negatively impact the reference utility and therefore the estimated demand for conventional cowpea; however, the lowest income which should be positively related to the reference utility seems to have a positive impact on the utility of reference and therefore on the estimated demand for conventional cowpea; the results also seem to imply that the demand for conventional cowpea is lower in a household where the primary decision-maker for food purchase has attended a western-based school; similarly, the demand for conventional cowpea seems to be higher in a household where the cowpea purchased is mostly white; it is also higher in a household that is self-insured against risks compared to a non-insured household

Ex Ante Economic Impact of Bt Cowpea

The previous estimated Hicksian demand functions can be used to estimate the net economic impact of Bt cowpea on cowpea growers and consumers in Benin. The estimated Hicksian demand functions for producers suggest that the introduction of Bt cowpea in Beninese markets would have the following impacts:

- Decrease of about 60% in total cowpea production costs: the adoption of Bt cowpea implies a reduction in insecticide use and therefore, a reduction in the costs of producing cowpea; this cost reduction implies that seed requirements are the same for both Bt and conventional cowpea and that both seeds are sold at the same average market prices
- Decrease in cowpea yield by about 11%: most farmers are currently using chemical insecticide to get high cowpea yield; once informed of Bt cowpea, these farmers state that they would use no insecticide with Bt cowpea, and are therefore willing to risk losing some cowpea harvest

The combination of these two effects implies a net decrease in the marginal cost of producing cowpea by about 15%. The net impact of Bt cowpea on cowpea supply in Benin is illustrated in Figure 2, which also presents aggregate estimated Hicksian demand functions for both Bt and conventional cowpea in Benin. The net impact of Bt cowpea on Beninese cowpea supply reflects an estimated net proportional change in cowpea production costs with respect to cowpea price. This net proportional cost change is presented by Masters et al. (1996): $k = (J / \varepsilon) - c$ where J reflects the change in production due to Bt cowpea as a proportion of total production, ε is the price elasticity

of supply and c corresponds to the adoption costs of the new technology, as a proportion of product price. The variable "k" was computed for each surveyed cowpea grower and the average value of 'k" across all farmers was then applied to an estimate of the aggregate supply of conventional cowpea in Benin to obtain an estimate of the aggregate supply of Bt cowpea in Benin. The estimated aggregate supply of conventional cowpea was obtained from Langyintuo (2003).

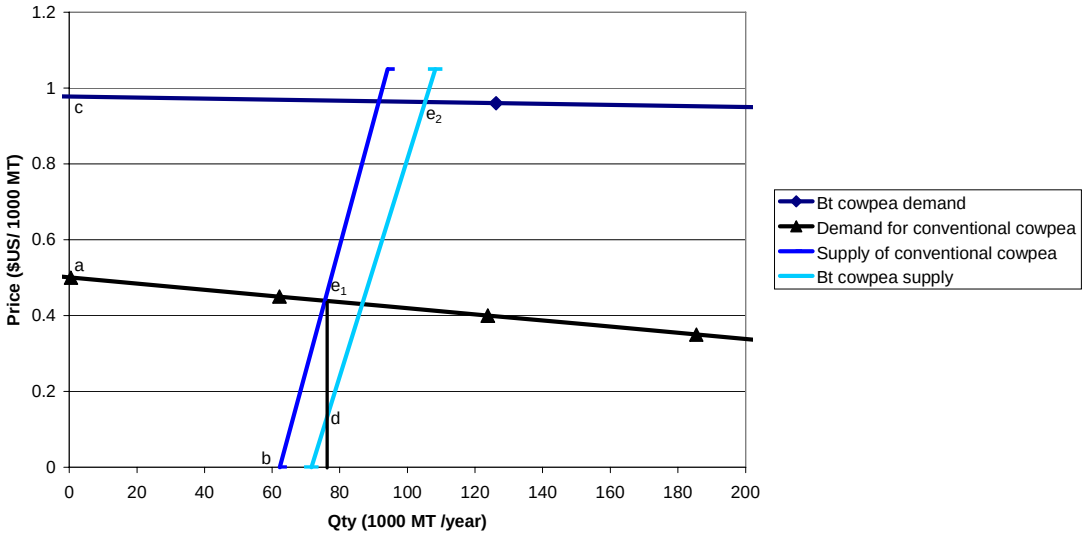


Figure 2: Estimated Aggregate Demand and Supply Functions for Bt and Conventional Cowpea - Benin

Most of the surveyed cowpea growers in Benin use non-recommended chemical insecticide (cotton insecticide) for pest control in cowpea. Cowpea is very vulnerable to field insect pests, and cotton insecticides are more affordable than insecticides recommended for cowpea. Beninese farmers can access cotton insecticide via two means: a formal channel in which cotton growers can buy cotton insecticide on credit from a

farmers' cooperative or an informal channel where non-cotton growers buy insecticides from cotton growers. At the beginning of the growing season, cotton growers in Benin receive on credit cotton production inputs including cotton insecticides; they usually do not allocate all their cotton insecticides to cotton production only and the surplus is therefore made available for other crops and other farmers.

During the market simulation for the choice experiment questionnaire, farmers were told that with Bt cowpea, they would use very little insecticide, or no insecticide at all and yet get the same yield obtained with conventional cowpea grown with chemical insecticide. In case of a severe infestation by pests not controlled by Bt, they would be using a maximum of a third of what they currently use with conventional cowpea for the same yield. To this, the majority of Beninese farmers opt for buying Bt cowpea and no insecticide. These farmers are currently misusing non-recommended insecticide (cotton insecticide) with cowpea to the detriment of their health and the health of their family members (Pesticide News, 2000). The potential yield gain associated with using cotton insecticide to grow Bt cowpea provides lower benefits to these farmers compared to the gains in health quality they would experience within their families were they to completely forgo using this insecticide with Bt cowpea. A few farmers systematically chose to use insecticide along with Bt cowpea. It is likely that these farmers believe that they have a better mastery of using chemical insecticide with cowpea.

Based on Figure 2, Beninese consumers seem on aggregate to prefer Bt to conventional cowpea: they believe Bt cowpea to be safer than its conventional counterpart that is produced and sometimes conserved with non-recommended insecticide. There have also been casualties in cities and villages in Benin due to families consuming cowpea produced and/or conserved with cotton insecticide. People are aware of this and therefore are very wary of the conventional cowpea sold on Beninese markets.

The changes that Bt cowpea causes on both demand and supply in Beninese cowpea markets can be used to estimate the net impact of Bt cowpea on societal welfare in Benin. Table 3 presents results from computing the potential net economic welfare change caused by Bt cowpea, if adopted in Benin. Based on Table 3, Beninese producers would experience a net welfare gain of about $US 51.9 million with the introduction of Bt cowpea. However, Beninese consumers would experience a net welfare loss of about $US 1.5 million with Bt cowpea: cowpea demand and supply would increase and become more elastic with the introduction of Bt cowpea; however, these changes would be much stronger on the demand side compared to the supply side, so that consumers would end up slightly losing with Bt cowpea. The welfare gain that Bt cowpea would bring to producers far outweigh the loss to consumers, so that the Beninese society would, on aggregate experience a net welfare gain of about $US 50.36 million. The net benefits provided by Bt cowpea are illustrated in Figure 2 and correspond to the area bordered by the points a, c, e_2, d and e_1.

The previous result is based on the assumption that Beninese farmers would be able to access Bt cowpea seeds when they need it. If the seed sector in Benin is assumed to experience inefficiencies implying that farmers can access Bt cowpea seeds only 50% of the time, then the Bt cowpea supply curve in Figure 2 will be cut in half. Producers will still gain with Bt cowpea, as shown in Table 9. However, their gain will be smaller compared to when inefficiencies in the seed sector are small enough to allow farmers to access Bt cowpea seeds when they need them. Consumers would experience a higher welfare loss in relation to Bt cowpea given the inefficiencies in the seed sector.

Table 3: Estimated Net Economic Impact of Bt Cowpea in Benin

	No inefficiencies in seed sector	Inefficiencies in seed sector
Producers	$51,907,532.47	$12,671,479.23
Consumers	-$1,547,166.09	-$2,123,758.12
Society	$50,360,366.39	$10,547,721.11

Conclusions and Policy Implications

The paper aimed at estimating the ex ante socio-economic impact of Bt cowpea in Benin under various scenarios on the economic state of the country's seed sector. The hypotheses to be tested implied that Bt cowpea would increase expected net welfare by 15% given no inefficiencies in the seed sector and that the benefits from Bt cowpea would be cut in half if inefficiencies in the seed sector implied that Beninese farmers can access Bt cowpea seeds only 50% of the time. The study results partially confirm the first hypothesis: expected net social welfare would increase with Bt cowpea in Benin;

however, as illustrated in Figure 2, Bt cowpea would more than double expected net social welfare: the area reflecting the increase in net benefits provided by the Bt cowpea (area bordered by the points a, c, e_2, d and e_1) is more than double the area reflecting the benefits provided by conventional cowpea (area bordered by the points a, e_1, b and 0). The study also partially confirms hypothesis 2. Based on Table 2, the net benefits provided by Bt cowpea are lower when the seed sector experiences inefficiencies implying that farmers can access Bt cowpea seeds 50% of the time. However, these net benefits would decrease by a factor of almost 5 and not 2 as stated in Hypothesis two. The results from the study imply that the Beninese population is accepting of Genetically Modified cowpea. Farmers view Bt cowpea as a way to improve cowpea yield in a safer way; consumers also view Bt cowpea as a safer source of food compared to conventional cowpea. Now, policies should be oriented towards improving the ability of the seed sector in the region to provide reliable services to Beninese farmers.

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Appendix A

Survey Questionnaire for Producers

- Imagine that it is the beginning of the cropping season and that you are actually in the market or the store where you usually buy agricultural inputs
- In this market or store, you see me, and I am a seller of agricultural inputs; imagine also that you can not find elsewhere products with the same quality at cheaper prices
- Seller says:
    - I am selling two types of cowpea seeds:
        - Traditional cowpea seeds:
            - **Disadvantage**: you will probably have to use chemical insecticide during the cropping season if you use conventional cowpea seeds; chemical insecticides are effective at controlling pest infestation, but they cause health hazards when they are mishandled and using them correctly requires training and expensive equipments; moreover, insecticide residues can remain on food products and cause health problems to consumers
            - **Advantage**: producers and consumers know this product; you, as a producer, have a quite precise idea on the financial and health impacts that this seeds provides within your household
        - Genetically Modified (GM) cowpea:
            - **Advantage**: if you plant Bt cowpea, you will use very little chemical insecticide and in some cases, no insecticide at all. In case of major force, if you have to use insecticide, the maximal quantity of insecticide you would be using would correspond to one-third of the quantity used with conventional cowpea seeds for a same yield. With Bt cowpea, there is no health problem related to misusing the seed; you can treat this seed as if it was a conventional seed: you plant it and then watch it grow. Most of the insects attacking leaves, flowers, buds, and pods of cowpea plants die, so that Bt cowpea can be produced with very little insecticide and in some cases, with no insecticide at all
            - **Disadvantage**: the long term health impact of GM cowpea is currently unknown; people have been eating GM corn and soybean everyday for 10 years now in the US without any problems but the long term health impact of GM food is currently unknown
    - As a cowpea grower, you will have to buy Bt cowpea seeds every 3 or 4 years

- Note that consumers will not be able to make any difference between Bt and conventional cowpea: both have the same taste and they are both visually identical; they also have the same culinary characteristics
- All of what I just told you is the truth: this seed has been tested in the region and results from the test confirmed what I am telling you about this new seed
- If I tell you:
    - The price of this 'togolo[1]' of Bt cowpea seeds is _____ ; take it or leave it;
    - The price of this 'togolo' of traditional cowpea seeds is _____ ; take it or leave it;
    - The price of this package of insecticide is _____ ; take it or leave it;
    - Do not forget that you cannot find elsewhere products with the same quality at cheaper prices
- Which type of cowpea would you like to buy? Would you prefer to buy none of the cowpea offered here?
- How many togolos of cowpea would you buy at these prices? Choose the quantity that you are sure to buy regardless of the weather during the cropping season; in other words, choose the quantity that you are sure to buy whether rainfall during the season is good or bad
- How many packages of insecticide would you buy?

[1] Togolo: unit measure for cowpea sale; One 'togolo' of cowpea equals 1 kilogram of cowpea

Survey Questionnaire for Consumers of Cowpea

- Imagine that you are currently in the market (or the shop) where you want to buy food products. You are in front of me, a cowpea seller. Imagine also that you cannot find elsewhere products with the same quality at cheaper prices.
- Seller says:
    - I am selling two types of cowpea:
        - Conventional cowpea:
            - **Disadvantage**: this cowpea ***could have*** been treated with chemical insecticide; these insecticides are very effective for controlling cowpea pests, but they involve health problems for cowpea growers when they are mishandled. Moreover, insecticide residues can remain on food products and cause health problems to consumers
            - **Advantage**: you know this product; you see this product in the market and you have a quite precise idea of its health and financial impacts on your household
        - Genetically Modified (GM) Cowpea:
            - **Advantage**: GM cowpea has been genetically modified to substantially reduce insecticide use and therefore potentially reduce health problems for both producers and consumers; most insects attacking leaves, flowers, buds, and pods on GM cowpea plants die; therefore, GM cowpea can be produced with very little insecticide and in some cases without any insecticide at all
            - **Disadvantage**: The long term health impact of GM cowpea is currently unknown; people have been eating GM corn and soybean everyday for 10 years now in the US without any problems but the long term health impact of GM food is currently unknown
    - There is no difference between GM and conventional cowpea: they both have the same taste and they are visually identical; moreover, they also have the same culinary characteristics
    - All of what I just told you about these two products is true; if it wasn't, would I also tell you about their disadvantages?
    - If I tell you:
        - The price of a 'togolo[2]' of GM cowpea is _____ ; take it or leave it;
        - The price of a 'togolo' of conventional cowpea is _____ ; take it or leave it;
        - Do not forget that you cannot elsewhere products of the same quality at cheaper prices
    - Which type of cowpea would you buy? Would you prefer none of the cowpea offered here?

[2] Togolo: unit measure for cowpea sale; One 'togolo' of cowpea equals 1 kilogram of cowpea

- How many ‘togolos’ of cowpea would you buy at these prices? Choose quantities you are sure to buy regardless of your monthly income

Cheap Talk Script

In few minutes, you will be asked questions on whether you would buy a new product at a particular price. However, before you answer the questions, I would like to inform you about something.

People tend to say one thing and do another. In a previous study done in Nigeria, people were asked whether or not they wanted to buy a new product, a little bit similar to the one you are about to be asked about. This purchase was not a real one for these people, just as it will also not be for you. No one actually had to pay money once they agreed upon a price for the new product, the Insecticide-Treated Net (ITNs). About 21 people said that they would be willing to pay at least 350 Naira for the insecticide-treated net. Among those, some said that they were willing to pay more than 350 Naira for one net. When, few days later, the nets were actually offered for sale at 350 Naira each, when people really had to pay money if they decided to purchase the net, only 10 actually bought it. 10 out of 21 people, this is quite a difference, isn't it?

One explanation for this is that people behave differently when they are in a fictional shopping situation where they will not spend any money at all compared to when they are actually in the market or store where they will have to spend money if they decide to buy something.

I would like to ask you to answer the following purchase questions exactly as if you were in the market or the store where you would have to face the consequences of your decisions, which is to pay money if you decide to buy something.