MULTI-COUNTRY ASSESSMENT OF BARRIERS TO ACCEPTANCE OF GM RICE

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Selected Paper prepared for presentation at the SAEA 2015 Annual Meeting, Atlanta, Georgia, February 2-3, 2015

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Abstract

Genetically modified (GM) rice has been developed to confer pest resistance, herbicide tolerance and health benefits, yet regulatory, policy and market barriers prevent commercialization of GM rice. This study assesses factors based on consumer survey results that assess acceptance of GM rice in 5 selected countries, namely, Bangladesh, Colombia, Ghana, Honduras, and Tanzania.

Keywords: GM rice, consumer willingness to pay,

JEL Classification codes: D12, Q16, Q51

INTRODUCTION

Meeting world food needs is a fundamental challenge as global population is expected to increase to more than 9 billion by 2050. Rice is one of the major crops that feed the world (accounting for 19% of global food calories, UN FAOSTAT).

GM technology has been adopted worldwide except for food grain crops, rice and wheat. It has generated sizable economic benefits to the adopters, many in the developing world (Brooks and Barfoot, 2014). Despite the benefits associated with this technology, to date no GM food crop, including rice, have been commercialized at a large scale (Demont and Stein, 2013).

Despite the barriers to commercialization, research and development of GM rice continues, focusing on agronomic and nutritional improvements to stabilize production and improve the well-being of consumers.

While consumer acceptance has been well studied in many developed countries and regions such as the U.S. and the EU, developing countries have been less frequently studied. This study examines barriers to acceptance and use of GM rice at the global level through the implementation of consumer surveys in five selected developing countries with varying rice market characteristics.

METHODOLOGY

Consumer surveys were conducted in five countries, namely, Bangladesh, Colombia, Ghana, Honduras, and Tanzania, to assess consumers' willingness to pay (WTP) for GM rice. The samples were obtained following a convenient sampling approach as follows:

Bangladesh: 219 consumers from Dhaka, Gazipur, Mymensingh and Dinajpur;
Colombia: 200 consumers from four different locations in Bogota;
Ghana: 206 consumers from selected locations in Accra and Tamale;
Honduras: 200 consumers from 3 different locations in San Pedro Sula;
Tanzania: 200 consumers from selected locations in Dar Es Salaam.

The surveys include four science-based information treatments, namely:

- Neutral, no information provided (TREAT_NEU)
- Environmental GM, providing information about GM rice with agronomic benefits, such as *Bt* rice (TREAT_E);

- Nutritional GM, providing information about GM rice with health benefits, such as vitamin A enhancing golden rice (TREAT_N);
- Stacked GM rice, providing information about both environmental plus nutritional benefits obtained through GM rice, such as *Bt* rice plus golden rice (TREAT_S)

Information ordering effects (benefits presented first vs. risks first) were tested. Double bounded dichotomous choice (DBDC) questionnaires with 5 different GM rice starting prices were used. Socio-demographic questions were also included. Consumer data were analyzed following the procedure by Lopez-Feldman.

RESULTS AND DISCUSSION

Table 1 below shows the socio-demographic characteristics of the samples by country. The vast majority of respondents had no knowledge about GM rice prior to the survey. The variable objective knowledge reflects the correct response to an objective knowledge question included in the questionnaire.

There is significant variability on gender across countries, which reflects cultural differences. While women are primarily in charge of purchasing groceries, including rice, in Colombia and Honduras, buying rice is primarily a male responsibility in Bangladesh, where households usually buy rice in large (40 Kg) bags.

Income distribution is skewed to the right in Bangladesh, Colombia, and Honduras, heavily skewed to the right in Tanzania, and heavily skewed to the left in Ghana. Comparing the income distribution of the sample from Colombia to country-level statistics reported by Angulo et al. (2013)[1] and UNDP (2013), we can argue that the middle and high income class is overrepresented in the sample, while the low income class is underrepresented. UNDP (2013) reports that in 2012, 56.4% of the population in Honduras qualified as poor, 29.9% as vulnerable, 12.8% as middle class, and the remaining 0.9% as high class. Hence, relative to UNDP statistics, our sample is highly skewed to the left, with an overrepresentation of the middle and high class.

Across countries, most respondents are between 21 and 45 years old, belong to a medium-size household, and hold a college degree. Respondents from Bangladesh and Honduras have the largest share of their income spent on food. Finally, at least a third of respondents across countries eat rice at least 15 times a week, with Honduras and Colombia having the largest share of respondents in that category.

Table 2 presents the average WTP for GM rice across all traits by country. Honduran consumers reveal the largest premium for GM rice, willing to pay over half the price of regular rice for GM varieties. Consumers from Bangladesh and Colombia are also willing to pay a premium for GM rice of around 12%.

On the other hand, consumers from Tanzania and Ghana reveal their willingness to pay for GM rice at a discount vis-à-vis conventional rice. The WTP for GM rice across the full sample was estimated at USD 0.15/Kg in Ghana and USD 0.93/Kg in Tanzania.

1 Angulo et al. (2013) estimates that around 71.2% of the population in 2011 was in a vulnerable situation associated with low income, 26.5% qualified as middle class, and only 2.4% qualified as high income class.

Table 1Consumer surveys: socioeconomic characteristics by country

Variable	Bangladesh (N = 219)	Colombia (N = 200)	Ghana (N = 206)	Honduras (N = 200)	Tanzania (N = 200)
Objective knowledge	0.0%	7.5%	13.6%	1.0%	6.5%
Female	4.6%	65.5%	44.7%	77.5%	44.5%
Income					
Low [1]	37.0%	49.0%	4.4%	59.5%	86.5%
Medium [2]	51.1%	40.0%	12.6%	32.0%	11.5%
High [3]	11.9%	11.0%	83.0%	8.5%	2.0%
Age					
<= 20 years	0.0%	4.0%	3.4%	3.0%	4.0%
21 - 45 years	57.6%	51.5%	83.0%	63.5%	83.0%
46 - 60 years	33.3%	34.0%	11.2%	22.0%	13.0%
> 60 years	9.1%	10.5%	2.4%	11.5%	0.0%
Education					
<= primary school	18.7%	4.0%	1.9%	28.5%	17.5%
High school	23.3%	42.5%	14.1%	34.5%	34.5%
College degree	35.2%	46.0%	58.7%	35.0%	39.5%
Graduate degree	22.8%	7.5%	25.3%	2.0%	8.5%
Income share on food					
<= 10%	0.9%	9.5%	8.3%	2.0%	18.5%
11% - 15%	3.2%	17.5%	18.5%	6.0%	16.5%
16% - 25%	11.0%	32.5%	28.6%	19.5%	22.5%
26% - 45%	29.2%	25.0%	29.6%	27.5%	27.5%
> 45%	55.7%	15.5%	15.0%	45.0%	15.0%
Household size					
Small [4]	18.7%	18.5%	36.9%	35.0%	34.0%
Medium [5]	58.0%	53.5%	41.3%	40.5%	37.0%
Large [6]	23.3%	28.0%	21.8%	24.5%	29.0%
> 15 rice meals/week	33.8%	48.0%	41.3%	59.0%	32.5%

1. Bangladesh: < Tk 17,500; Colombia: < $C 3 million; Ghana: < GH¢ 100; Honduras: < L 10,000; Tanzania: < TZS 960,000.
2. Bangladesh: Tk 17,500 - Tk 35,000; Colombia: $C 3 million - $C 9 million; Ghana: GH¢ 100 - GH¢ 300; Honduras: L 10,000 - L 30,000; Tanzania: TZS 960,000 - TZS 1,920,000.
3. Bangladesh: > Tk 35,000; Colombia: > $C 9 million; Ghana: > GH¢ 300; Honduras: > L 30,000; Tanzania: > TZS 1,920,000.
4. Bangladesh: < 4 people; Colombia: < 3 people; Ghana: < 5 people; Honduras: < 4 people; Tanzania: < 4 people.
5. Bangladesh: 4 to 5 people; Colombia: 3 to 4 people; Ghana: 5 to 7 people; Honduras: 4 to 5 people; Tanzania: 4 to 5 people.
6. Bangladesh: > 5 people; Colombia: > 4 people; Ghana: > 7 people; Honduras: > 5 people; Tanzania: > 5 people.

Based on the WTP estimates and the reference price of non-GM rice, the findings suggest consumers on average in Ghana and Tanzania are willing to accept GM rice with a discount of 85.7% and 1.9%, respectively. The high discount by Ghanaian consumers to accept GM rice is striking, but likely influenced by highly skewed household incomes of the sample.

Table 2 Average WTP for GM rice and premium over conventional rice by country

	Bangladesh	Colombia	Ghana	Honduras	Tanzania
Average WTP (USD/Kg)	0.58	1.41	0.15	1.35	0.93
GM Rice Premium (%)	11.8	11.6	-85.7	52.9	-1.9

Following is a discussion of the main findings from the WTP DBDC model estimates for each country.

Bangladesh

We find no statistically significant evidence of information treatment effect, ordering effect, or interaction of treatment/ordering. Education is the only socio-demographic variable showing a significant negative effect on WTP. For instance, a consumer with a college degree is willing to pay USD 0.06/Kg less than another holding a high school degree.

Table 3 Bangladesh: estimation results of the DBDC model for WTP

Variable	Coefficient[1]	Std. Err.	z	P>|z|
TREAT_E	121.73	365.03	0.33	0.74
TREAT_N	30.23	370.31	0.08	0.94
TREAT_S	465.00	373.40	1.25	0.21
ORDER	-116.35	189.63	-0.61	0.54
EDU	-191.85**	80.96	-2.37	0.02
Constant	2526.43	210.52	12.00	0.00
	Log likelihood = -284.4		***Wald chi2(5) = 10.91***	
	Number of obs. = 219		***Prob > chi2 = 0.053***	

Note: *, **, *** denote significance at 10%, 5%, and 1%, respectively.

1. Coefficient unit: Tk/40 Kg.

Colombia

The results from the CV analysis indicate a positive effect of the interaction stacked treatment with risks first ordering (TREAT_SR). Colombian consumers receiving information about stacked GM rice with risks first ordering are willing to pay USD 0.73/Kg more than those receiving a neutral information treatment. No socio-demographic variable is found to be a significant explanatory variable of WTP.

Table 4 Colombia: estimation results of the DBDC model for WTP

Variable	Coefficient[1]	Std. Err.	z	P>|z|
TREAT_EB	-55.57	641.39	-0.09	0.93
TREAT_ER	-693.79	650.27	-1.07	0.29
TREAT_NB	2.55	616.28	0.00	1.00
TREAT_NR	-155.66	635.29	-0.25	0.81
TREAT_SB	281.51	636.84	0.44	0.66
TREAT_SR	1770.87**	773.24	2.29	0.02
Constant	2674.78	367.41	7.28	0.00
	Log likelihood = -202.0		***Wald chi2(6) = 7.95***	
	Number of obs. = 200		***Prob > chi2 = 0.242***	

Note: *, **, *** denote significance at 10%, 5%, and 1%, respectively.

1. Coefficient unit: C$/Kg.

Ghana

We find evidence that the interaction environmental treatment with risks first affects the WTP of respondents; more specifically, this interaction has a positive impact of USD 1.01/Kg on consumers' WTP (relative to the neutral treatment). Prior knowledge about GM rice has a positive marginal effect on WTP estimated at USD 0.53/Kg.

Among the socio-demographic control variables, the share of income spent on food has a statistically significant negative effect on WTP. The larger the share of income spent on food, the lower the negative marginal effect on WTP. Consumers spending between 11% and 15% of their income in food (INCSHR2) are willing to pay USD 1.53/Kg less than those spending 10% or less on food. The marginal effect of those consumers spending 45% or more of their income in food is estimated at USD 1.11/Kg.

Table 5 Ghana: estimation results of the DBDC model for WTP

Variable	Coefficient[1]	Std. Err.	z	P>|z|
TREAT_EB	1.88	5.93	0.32	0.75
TREAT_ER	16.65 ***	5.88	2.83	0.01
TREAT_NB	1.19	5.96	0.20	0.84
TREAT_NR	-2.22	6.20	-0.36	0.72
TREAT_SB	6.32	5.96	1.06	0.29
TREAT_SR	1.65	5.84	0.28	0.78
POK	8.73*	4.83	1.81	0.07
INCSHR2	-25.20 ***	7.87	-3.20	0.00
INCSHR3	-19.46 ***	6.86	-2.84	0.01
INCSHR4	-18.59 ***	6.97	-2.67	0.01
INCSHR5	-18.18**	7.46	-2.44	0.02
Constant	16.49	6.41	2.57	0.01
	Log likelihood = -183.7		***Wald chi2(11) = 18.54***	
	Number of obs. = 206		***Prob > chi2 = 0.070***	

Note: *, **, *** denote significance at 10%, 5%, and 1%, respectively.

1. Coefficient unit: *GH¢*/5 Kg.

Honduras

We find evidence that the interaction variable of environmental treatment with benefits first affects the WTP of respondents; more specifically this interaction has a negative impact of USD 0.11/Lb. on consumers' WTP (relative to the neutral treatment). No significant effect is observed for information treatment, ordering effect, or any other interaction treatment/ordering.

Female respondents have a positive view of GM rice vis-à-vis their male counterpart, expressed by a positive impact on GM rice WTP of around USD 0.08/Lb.

The WTP for GM rice decreases steadily with age and education level. For instance, people between 21 and 45 years of age are willing to pay USD 0.07/Lb. more than those above 60 years old. Likewise, respondents with a high school degree are willing to pay USD 0.07/Lb. more than those holding a graduate degree.

Income share spent on food is also a statistically significant explanatory variable negatively related to WTP for GM rice. Respondents spending less than 25% of their income in food are willing to pay USD 0.09/Lb. more than those having a food expenditure share above 25%.

Table 6 Honduras: estimation results of the DBDC model for WTP

Variable	Coefficient[1]	Std. Err.	z	P>|z|
TREAT_EB	-12.19 *	6.77	-1.80	0.07
TREAT_ER	-6.66	6.75	-0.99	0.32
TREAT_NB	-8.19	6.41	-1.28	0.20
TREAT_NR	-8.48	6.38	-1.33	0.18
TREAT_SB	-7.56	6.86	-1.10	0.27
TREAT_SR	-8.10	6.89	-1.18	0.24
POK	87.92	4069.54	0.02	0.98
FEMALE	8.45 **	4.35	1.94	0.05
INC	-2.10	3.28	-0.64	0.52
AGE	-7.10 ***	2.75	-2.58	0.01
EDU	-7.17 ***	2.58	-2.78	0.01
INCSHR	-9.36 *	4.91	-1.91	0.06
HHSIZE	0.14	1.03	0.14	0.89
Constant	87.52	10.42	8.40	0.00
	Log likelihood = -165.9		***Wald chi2(13) = 22.66***	
	Number of obs. = 200		***Prob > chi2 = 0.046***	

Note: *, **, *** denote significance at 10%, 5%, and 1%, respectively.

1. Coefficient unit: Lempiras/5 Lb.

Tanzania

We find no statistically significant evidence to explain variation in WTP using information treatment effect, ordering effect or interaction treatment/ordering. Furthermore, no socio-demographic variable shows significant explanatory power of WTP for GM rice.

CONCLUSIONS

As a major food staple the five countries studied, the consumer WTP estimates reflect large differences in the average premium or discount needed to accept GM rice. Consumers in Honduras were willing the pay the highest premium of 53% above the price of their regular

conventional rice. Consumers in Ghana however required an average price discount to purchase GM rice relative to conventional rice of 86%.

The findings in general suggest that science-based information treatments of alternative traits—*Bt* rice, Golden rice, stacked traits—generate little difference in the WTP estimates, with the exception of some interaction between information treatment and ordering effect in Colombia, Ghana and Honduras. Previous knowledge about GM rice is positively related to WTP for GM rice in Ghana.

Among socio-demographic variables, education helps partially explain WTP in Bangladesh and Honduras, showing a negative relationship with WTP for GM rice. Income share spent on food is negatively related to WTP for GM rice in Ghana. Finally, gender and age offer also significant explanation to WTP for GM rice in Honduras.

These results suggest that national government policies designed to promote acceptance of GM rice cannot rely upon a universal approach. While the consumer sample characteristics in the five country studies reflect major differences in some of the socio-demographic variables, we observed large differences in WTP across countries and differences in factors that influence WTP. Given the potential of GM rice as one approach to sustaining the environment and improving nutrition of diets of rice consumers, further study of consumers' willingness to accept GM rice in additional developing countries is warranted.

Table 7 Definition of independent variables considered in the estimation of WTP

Variable Name	Variable Description
POK	Previous knowledge about GM rice (1 = yes, 0 = no)
FEMALE	Gender (1 = female, 0 = male)
INC	Income level (0 = low, 1 = medium, 2 = high)
INC_LOW	Low income household (1 = low, 0 = otherwise)
INC_MED	Medium income household (1 = medium, 0 = otherwise)
INC_HIGH	High income household (1 = high, 0 = otherwise)
AGE	Age (0 = <= 20 years, 1 = 21-45 years, 2 = 45-60 years, 3 = > 60 years)
AGE1	Age <= 20 years (1 = <= 20 years, 0 = otherwise)
AGE2	Age 21-45 years (1 = 21-45 years, 0 = otherwise)
AGE3	Age 45-60 years (1 = 45-60 years, 0 = otherwise)
AGE4	Age > 60 years (1 = > 60 years, 0 = otherwise)
EDU	Education level (0 = elementary school, 1 = high school, 2 = college, 3 = graduate)
EDU1	Elementary school degree (1 = elementary school, 0 = otherwise)
EDU2	High school degree (1 = high school, 0 = otherwise)
EDU3	College degree (1 = college, 0 = otherwise)
EDU4	Graduate degree (1 = graduate, 0 = otherwise)
INCSHR	Income share spent on food (1 = > 25%,, 0 = otherwise)
INCSHR1	Income share spent on food <= 10% (1 = <= 10%, 0 = otherwise)
INCSHR2	Income share spent on food 11% - 15% (1 = 11% - 15%, 0 = otherwise)
INCSHR3	Income share spent on food 16% - 25% (1 = 16% - 25%, 0 = otherwise)
INCSHR4	Income share spent on food 26% - 45% (1 = 26% - 45%, 0 = otherwise)
INCSHR5	Income share spent on food > 45% (1 = > 45%, 0 = otherwise)
HHSIZE	Number of people living in the household
HHSIZE_SMALL	Small-size household (1 = small-size, 0 = otherwise)
HHSIZE_MED	Mid-size household (1 = mid-size, 0 = otherwise)
HHSIZE_LAR	Large-size household (1 = large size, 0 = otherwise)
MEALS	Number rice meals/week (1 = > 10, 0 = otherwise)

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