ANALYSIS OF U.S. RICE POLICY IN A GLOBAL STOCHASTIC FRAMEWORK

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ABSTRACT

U.S. rice policy is evaluated in this paper with a global modeling framework to examine the potential impacts of domestic policy reforms using stochastic analysis. Results of this study show that without government payments, the international rice price and U.S. farm price and their volatility will increase. For the U.S., rice area harvested, production, net exports, and the country's share in global net exports will decrease under a no-government-payment scenario. Analysis of trade of major exporting and importing countries indicates that volatility of international trade also increases under the same scenario. While unilateral elimination of government support for U.S. rice results in a decline in world net rice trade as a result of decreased purchases by major rice importers, the major rice net exporter competitors increase their share at the expense of the U.S. The stochastic analysis provides market insights as it shows how outcomes are empirically-distributed as opposed to the incomplete picture provided by point estimates generated by deterministic analysis.

Key words: Arkansas Global Rice Model, government payments, stochastic analysis, empirical distribution, deterministic analysis, rice trade

INTRODUCTION

U.S. farm commodity policies are being examined as the current legislation expires in 2012. There are a number of important pressures for reform of U.S. agricultural policy including burgeoning federal budget deficits, trade distortions and pressure from WTO members, and the on-going volatility of international agricultural commodity markets. U.S. rice policy is evaluated in this paper with a global modeling framework to examine the impacts of domestic policy reforms using both deterministic and stochastic analyses. This global rice stochastic analysis uses the Arkansas Global Rice Model to generate results showing the distribution of outcomes. It looks at the effects of removing U.S. government payments beginning in 2013 as it alters returns from rice and competing crops (corn, soybeans, and cotton), which in turn affects international rice prices, U.S. rice production and trade, and rice trade of selected major rice-producing and -consuming countries.

For a number of years, the Arkansas Global Rice Project, in collaboration with the agricultural commodity analysts/modelers of the Food and Agricultural Policy Research Institute (FAPRI), has prepared 10-year deterministic baseline projections for the U.S. and international rice markets. This deterministic baseline is used in analyzing the impacts of alternative scenarios dealing with policies, trade, and technology. As pointed out by

[1] James Smartt, Program Associate, Department of Agricultural Economics and Agribusiness, University of Arkansas, is acknowledged for assistance in developing the macro program for the stochastic simulation.

Westhoff et al. (2008), "actual market outcomes will deviate from the deterministic baseline values because many of the underlying assumptions will not hold true in practice." In this study, we use the AGRM model in a stochastic framework to analyze the impact of potential changes in U.S. rice policy, in addition to the typical deterministic analysis. While the deterministic baseline is useful in analyzing the impacts of alternative scenarios, the projections only provide point estimates assuming average values. The stochastic projections add analytical value by incorporating a risk component, allowing an assessment of the empirical distribution of the results over the period analyzed.

Westhoff et al. (2005, 2008) highlighted the importance of estimating a distribution of outcomes as opposed to point estimates in their study on evaluating World Trade Organization commitments on internal support measures, and farm and biofuel policies. They mentioned that "point estimates of agricultural and trade policy impacts often paint an incomplete or even misleading picture. For many purposes it is important to estimate a distribution of outcomes" (Westhoff et al., 2005). A stochastic framework is particularly useful in analyzing price support policies where the effects are typically asymmetric. Stochastic analysis has strategic importance also as a planning and policy decision-making tool, particularly for policies whose impacts are influenced by weather-induced uncertainties, very characteristic of the U.S. and the global rice economies.

METHODOLOGY

The Arkansas Global Rice Model (AGRM) which is used to develop the deterministic baseline is a multi-country econometric framework which has over 250 equations representing rice supply and demand relationships in 40 countries around the world. Countries or regions explicitly included in the model are Argentina, Australia, Bangladesh, Brazil, Cambodia, Cameroon, Canada, China, Cote D'Ivoire, Egypt, the European Union, Ghana, Guinea, Hong Kong, India, Indonesia, Iran, Iraq, Japan, Kenya, Malaysia, Mali, Mexico, Mozambique, Myanmar, Nigeria, Pakistan, the Philippines, Saudi Arabia, Senegal, Sierra Leone, South Africa, South Korea, Taiwan, Tanzania, Thailand, Turkey, United States, Uruguay, and Vietnam. All other countries are included in the five regional rest-of-the world (ROW) regions of Africa, Americas, Asia, Europe, and Oceania. Each region is comprised of several countries; and each country model has a supply sector, a demand sector, trade, and price linkage equations. All equations are either estimated using econometric techniques or are specified as identities. Estimates are based upon a set of explanatory variables including exogenous macroeconomic factors such as income, population, inflation rate, technology development, and country-specific policy variables. Other details and the theoretical structure and the general equations of the Arkansas Global Rice Model can be found in the documentation by Wailes and Chavez (2010).

The baseline projections are based on assumptions of current policies, macroeconomic variables, and average weather conditions. The stochastic framework used in this study is generated using empirical distributions of the yield variables. Yield is used because it is the variable that not only differs by region but is also very sensitive to changes in weather conditions and water availability--hence does vary widely from year-to-year, and from rice-

producing country-to-country. The deterministic baseline describes a single possible outlook. The stochastic analysis, on the other hand provides a range of values associated with risks and uncertainties in the future---issues that are not uncommon in the production of agricultural commodities. The 500 alternative futures used in this study assume yields that differ from one another but use the same current policies and exogenous variables as those of the deterministic baseline. Each run or alternative future in the stochastic analysis generates values for endogenous variables (prices, supply, demand and trade) for all the countries and regions covered in AGRM.

A two-step analysis is undertaken in this study:

1. As part of an annual undertaking, the international rice deterministic baseline is prepared in coordination with the Food and Agricultural Policy Research Institute (FAPRI). This baseline model version is estimated with government payments.

2. The deterministic baseline model is modified to generate a policy scenario outcome by removing the U.S. government payments from the net returns being read in the rice supply side equations, leaving only the market returns. This is done also with the net returns from other competing crops (corn, soybeans, and cotton) provided by FAPRI, which are used in some rice supply equations. The model is simulated until equilibrium is reached.

3. Results from the baseline and policy scenario simulations are summarized and selected variables are compared and analyzed.

4. The two deterministic simulations are modified such that values for all yield variables in the model are generated from correlated empirical distributions for 500 random draws.

5. Correlated empirical distributions are developed for yields (the selected exogenous variable) based on deviations from trends using 28 years of historical data (1983-2010). The program Simulation & Econometrics to Analyze Risk (SIMETAR) developed by Richardson et al. (2008) is used to develop the empirical distributions and random draws.

6. The model is simulated for the 500 random draws for each of the baseline and policy scenarios.

While there are many endogenous variables that could be analyzed from the model, for this paper analysis is limited to 17 key variables due to space considerations. These are the international rice price (Thai 100% B), U.S. long grain export price, U.S. medium grain export price, U.S. average farm price, U.S. area harvested, U.S. production, U.S. domestic consumption, U.S. net exports; and net exports for Thailand, Vietnam, India, Pakistan, and the world; and net imports for the Philippines, Nigeria, Bangladesh, and Indonesia.

For the stochastic analysis, the results include charts which show both the deterministic baseline mean values for the selected variable and a set of stochastic results that includes the stochastic mean, the 10^{th} and the 90^{th} percentiles in the outcome distribution for each year of the 10-year projection.

RESULTS AND DISCUSSION

Deterministic Model Results

The results of the first part of the study using deterministic analysis, comparing the baseline and policy scenario, are shown in Tables 1 through 4. The period presented in the deterministic analysis covers an eight-year period from 2013 through 2020 because the government payments based on the current farm bill expires in 2012 (i.e., no change in 2011 and 2012), and the current AGRM baseline projections extend only until 2020.

Table1 shows the scenario impact on rice prices and value of U.S. rice production. Without government payments, the international rice price represented by the Thai 100%B fob increases slightly as a result reduced U.S. exports and lower global net exports (bottom of Table 3). Changes in the Thai price range from +0.09% in 2014 to +0.71% in 2020 (or an average of +0.40% over the eight-year period) while global net trade declines by -0.06% in 2014 and by -0.55% in 2020 (or an average of -0.29%).

However, the U.S. long grain export price shows a decline of -0.39% in 2015 to -3.21% by 2020 (average of -1.46%), as the negative impact of lower U.S. long grain exports more than offset the positive effect of higher international price. However, the U.S. medium grain price fob California which is a proxy for international medium grain price increases slightly by +0.04% in 2014 and +0.18% in2020 (average of +0.13%), as supply-dampened declines in U.S. medium grain exports depress global net trade in medium grain rice. The U.S. average farm price, on the other hand, increases by +0.21% and +0.64% (average of +0.44%) over the same period, as a result of net declines in carry-over stocks in both long grain and medium grain, which more than offset the net effect of price changes in both rice types.

As expected for U.S. rice (Table 2), declines occur without government payments in all variables considered (area harvested, production, domestic consumption, net exports, and U.S. share in global rice exports). The main reason for the declines in harvested area which range from -1.45% in 2014 to -5.07% in 2020 (average of -3.25%) is the lower ratio of rice returns to competing crops' (corn, soybeans, and cotton) returns when the government payments are excluded. This result indicates that relative to the returns of competing crops, elimination of government payments places a greater burden on rice relative to competing crops.

Removing government payments causes production to decline by -2.97%, on the average. The combined changes in production and average farm price cause an average net decline in the total value of U.S. rice production of -2.51%. Changes in U.S. domestic consumption are small. Contractions in U.S. net exports range from -1.00% in 2014 to -7.85% in 2020 (or an average of -4.24% over the eight-year period) as available exportable supplies decline.

Table 3 shows the impact of the scenario (without government payments) on net exports of selected major rice exporting countries (Thailand, Vietnam, India, and Pakistan) and the world. Average change in India's net exports are negligible but for all three other major rice exporting countries, the average changes are positive, ranging from +0.06% to +0.30% over the eight-year period. In fact, results show that of all the major rice exporting countries only the U.S. shows substantial declines in net rice exports as a result of removing U.S. government payments.

For the selected major importing countries (Philippines, Nigeria, Bangladesh, and Indonesia), Table 4 shows that the same U.S. policy scenario has a negative impact on these countries' net imports, as the higher international prices dampen consumption. Average declines in net imports of these countries over the eight-year period range from -0.14% to -1.88%, led by Indonesia followed by Bangladesh, the Philippines, and Nigeria.

Stochastic Model Results

Tables 5a through 6b show the stochastic results with the full outcome distribution generated for two selected variables--the international rice price and the U.S. rice average farm price (with and without government payments). The period presented in the stochastic analysis covers a ten-year period from 2011 through 2020 to show the complete future outcome distribution, information which is important even for pre-scenario years (i.e., 2011 and 2012). Each table shows the deterministic baseline, the stochastic average, the standard deviation, and eleven percentiles (from 5^{th} through 95^{th}) of the empirical outcome distribution. Similar complete tables for all the other 15 variables are prepared but not presented in this paper to save space.

Tables 6a and 6b show that for the U.S. rice average farm price, all values are higher than the rice loan rate of $6.50 per cwt over the entire selected range of outcome distribution. This indicates that it is highly improbable in this baseline period for the average farm price to decline to a level close to $6.50 per cwt. In fact on the average, there is only about a 5% chance that the average farm price will be less than $10.75 per cwt over the period considered.

To match the eight-year deterministic analysis, a summary of the stochastic results showing the average changes in the 10^{th} and 90^{th} percentiles and the gap between the two values over the same eight-year period (2013-2020) for each variable is presented in Table 7. Intuitively, the gap between the two percentiles (10^{th} and 90^{th}) can be taken as a proxy for volatility. Widening indicates increased volatility and narrowing indicates decreased volatility.

The most important information in Table 7 is the rightmost set of three columns which shows not only that the international rice price increases as a result of removing government payments, but the volatility of the same price also increases. Over the eight-year period, the average value of the 10^{th} percentile increases +0.50% and that of the 90^{th} percentile gains by +0.90%, and the average gap between the two lines widened by 2.0%.

Table 7 also shows that with the exception of U.S. production and consumption, and net imports of Nigeria and Bangladesh, all the average gaps between the 10^{th} 90^{th} percentiles of the outcome distribution of the other thirteen other variables widened under the case of no government payments. This confirms the increased volatility not only in the international price but in the global rice trade in general—considering that the top global rice players are included in this analysis.

In order to show representative samples of the direction and spread of the stochastic outcome distribution, three selected outcome items (stochastic average, 10^{th} percentile, and 90^{th} percentile for both cases (with and without government payments) for six selected variables are presented in Figures 1 through 6.

Figure 1 and Tables 5a and 5b show additional interesting information on the international rice price. While the deterministic and stochastic means of the international rice price for both the baseline and policy scenario lie generally between $500 and $600 over the same period, the stochastic distribution indicates that 10% of the time the average price will be higher than $623 with U.S. government payments and higher than $628 without government payments. Further the international reference price is projected to be lower than $455 with U.S. government payments and lower than $457 without government payments 10% of the time. This feature of the stochastic analysis provides added value as it indicates how the outcomes are distributed, an analytic limitation of the average point estimates generated by deterministic analysis. The same kind of stochastic analysis can be made for each variable as presented in Figures 2 through 6.

Likewise, the corresponding probability distribution function (pdf) approximations at 95% confidence level for the six selected variables generated from SIMETAR are presented in Figures 7 through 12. The probability distribution describes the range of possible values that the selected variable can attain and the probability that the value of the variable is within any subset of that range. These pdf figures are presented simply as a quick reference for readers who may be interested to see representative shapes of the probability distribution functions of variables considered in this paper, given the output of 500 alternative futures generated from the 500 stochastic runs, with government payments.

Results of this study show that eliminating government payments will cause the international rice price and U.S farm price and their volatility to increase. Under the same scenario, U.S. rice area harvested, production, value of production, net exports, and the country's share in global net exports will decrease. Results also indicate that without government payments, greater burden is placed on rice returns relative to those of competing crops. Likewise, international trade and its volatility increase. While unilateral elimination of government support for U.S. rice causes a decline in world net rice trade as a result of decreased purchases by major rice importers, the major rice net exporting competitors increase their market share at the expense of the U.S.

Stochastic analysis is useful as it provides added market insight, relative to deterministic analysis, in generating distribution of possible outcomes that incorporates risks and uncertainties which is a characteristic of the U.S. and the global rice economies.

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Table 1. Comparison of deterministic rice price and returns, with and without government payments

Variables	2013	2014	2015	2016	2017	2018	2019	2020	Average
Thai 100%B fob	U.S. Dollars per Metric Ton (milled basis)								
With government payments	504.91	514.69	528.08	542.32	537.75	561.61	565.79	587.69	542.85
Without government payments	504.91	515.18	529.30	544.33	540.31	564.82	569.39	591.86	545.01
Level difference	0.00	0.49	1.22	2.01	2.57	3.21	3.60	4.17	2.16
Percent difference	0.00%	0.09%	0.23%	0.37%	0.48%	0.57%	0.64%	0.71%	0.40%
U.S. Long Grain Export Price	U.S. Dollars per Metric Ton (milled basis)								
With government payments	541.68	539.86	545.10	556.18	558.46	574.55	575.62	588.18	559.95
Without government payments	541.68	540.16	542.95	550.46	549.01	561.18	559.31	569.30	551.76
Level difference	0.00	0.31	-2.15	-5.72	-9.45	-13.38	-16.31	-18.88	-8.20
Percent difference	0.00%	0.06%	-0.39%	-1.03%	-1.69%	-2.33%	-2.83%	-3.21%	-1.46%
U.S. Medium Grain Export Price	U.S. Dollars per Metric Ton (milled basis)								
With government payments	773.63	786.31	793.45	797.69	805.29	808.73	816.14	823.73	800.62
Without government payments	773.63	786.60	794.28	799.02	806.17	810.57	817.75	825.22	801.65
Level difference	0.00	0.28	0.83	1.33	0.87	1.83	1.61	1.49	1.03
Percent difference	0.00%	0.04%	0.10%	0.17%	0.11%	0.23%	0.20%	0.18%	0.13%
U.S. Average Farm Price	U.S. Dollars per Cwt (rough basis)								
With government payments	12.79	12.63	12.56	12.10	12.83	12.50	11.98	11.92	12.41
Without government payments	12.79	12.65	12.61	12.17	12.91	12.57	12.06	12.00	12.47
Level difference	0.00	0.03	0.05	0.06	0.07	0.07	0.08	0.08	0.05
Percent difference	0.00%	0.21%	0.40%	0.53%	0.57%	0.58%	0.63%	0.64%	0.44%
Total U.S. Value of Rice Production	Million U.S. Dollars								
With government payments	2,983.9	2,976.2	2,977.3	2,915.0	3,138.3	3,105.8	3,035.4	3,054.0	3,023.25
Without government payments	2,983.9	2,942.6	2,919.2	2,840.3	3,041.0	2,996.3	2,922.5	2,933.4	2,947.40
Level difference	0.00	-33.61	-58.02	-74.69	-97.32	-109.60	-112.97	-120.53	-75.84
Percent difference	0.00%	-1.13%	-1.95%	-2.56%	-3.10%	-3.53%	-3.72%	-3.95%	-2.51%

Table 2. Comparison of deterministic U.S. rice estimates, with and without government payments (rough basis)

Variables	2013	2014	2015	2016	2017	2018	2019	2020	Average
Area Harvested			Thousand Acres						
With government payments	3,191.2	3,195.9	3,184.0	3,201.7	3,221.7	3,246.2	3,284.6	3,296.1	3,227.67
Without government payments	3,191.2	3,149.4	3,102.6	3,093.3	3,091.9	3,099.2	3,126.9	3,128.8	3,122.91
Level difference	0.00	-46.46	-81.41	-108.42	-129.81	-147.06	-157.71	-167.27	-104.77
Percent difference	0.00%	-1.45%	-2.56%	-3.39%	-4.03%	-4.53%	-4.80%	-5.07%	-3.25%
Production			Million Cwt						
With government payments	233.3	235.7	237.1	240.8	244.5	248.5	253.3	256.1	243.68
Without government payments	233.3	232.6	231.6	233.4	235.6	238.3	242.4	244.5	236.45
Level difference	0.00	-3.15	-5.54	-7.42	-8.92	-10.16	-10.95	-11.67	-7.23
Percent difference	0.00%	-1.34%	-2.34%	-3.08%	-3.65%	-4.09%	-4.32%	-4.56%	-2.97%
Domestic Consumption									
With government payments	128.4	126.5	128.8	130.6	132.3	134.2	136.0	137.5	131.79
Without government payments	128.4	126.5	128.8	130.6	132.3	134.2	136.0	137.6	131.79
Level difference	0.00	-0.01	-0.01	-0.02	0.00	0.00	0.02	0.04	0.00
Percent difference	0.00%	0.00%	-0.01%	-0.01%	0.00%	0.00%	0.01%	0.03%	0.00%
Net Exports									
With government payments	104.5	103.6	103.9	106.2	105.7	108.0	110.8	115.2	107.24
Without government payments	104.5	102.6	101.5	102.2	100.3	101.3	103.0	106.2	102.69
Level difference	0.00	-1.03	-2.44	-3.97	-5.36	-6.67	-7.82	-9.04	-4.54
Percent difference	0.00%	-1.00%	-2.35%	-3.74%	-5.08%	-6.17%	-7.06%	-7.85%	-4.24%
U.S. Net Export Share			Percent						
With government payments	10.79%	10.22%	10.05%	10.11%	9.79%	9.86%	9.98%	10.10%	10.11%
Without government payments	10.79%	10.12%	9.83%	9.76%	9.33%	9.29%	9.32%	9.35%	9.72%
Level difference (points)	0.00%	-0.10%	-0.22%	-0.35%	-0.47%	-0.57%	-0.66%	-0.74%	-0.39%
Percent difference	0.00%	-0.94%	-2.21%	-3.51%	-4.76%	-5.78%	-6.60%	-7.33%	-3.84%

Table 3. Comparison of deterministic net exports of major exporting countries, with and without government payments

Variables	2013	2014	2015	2016	2017	2018	2019	2020	Average
Thailand				Thousand Metric Tons					
With government payments	9,676	10,882	10,941	11,048	10,861	11,130	11,333	11,884	10,969.37
Without government payments	9,676	10,888	10,950	11,056	10,869	11,137	11,339	11,890	10,975.80
Level difference	0.00	5.62	8.67	8.76	7.66	7.59	6.26	6.86	6.43
Percent difference	0.00%	0.05%	0.08%	0.08%	0.07%	0.07%	0.06%	0.06%	0.06%
Vietnam									
With government payments	6,125	6,153	6,267	6,530	6,361	6,389	6,498	6,471	6,349.01
Without government payments	6,125	6,158	6,279	6,548	6,384	6,417	6,529	6,507	6,368.37
Level difference	0.00	5.35	11.91	18.47	23.62	28.44	31.51	35.53	19.35
Percent difference	0.00%	0.09%	0.19%	0.28%	0.37%	0.45%	0.49%	0.55%	0.30%
India									
With government payments	2,745	2,585	2,727	2,387	3,565	3,313	3,331	3,393	3,005.80
Without government payments	2,745	2,584	2,726	2,386	3,565	3,313	3,331	3,393	3,005.53
Level difference	0.00	-0.34	-0.48	-0.47	-0.34	-0.26	-0.13	-0.12	-0.27
Percent difference	0.00%	-0.01%	-0.02%	-0.02%	-0.01%	-0.01%	0.00%	0.00%	-0.01%
Pakistan									
With government payments	3,604	3,531	3,590	3,612	3,495	3,652	3,499	3,536	3,564.95
Without government payments	3,604	3,534	3,595	3,621	3,507	3,666	3,517	3,555	3,574.81
Level difference	0.00	2.26	5.44	8.64	12.51	13.97	17.50	18.57	9.86
Percent difference	0.00%	0.06%	0.15%	0.24%	0.36%	0.38%	0.50%	0.53%	0.28%
World									
With government payments	30,479	31,903	32,536	33,039	33,956	34,468	34,935	35,916	33,404.11
Without government payments	30,479	31,885	32,490	32,959	33,844	34,325	34,765	35,717	33,308.06
Level difference	0.00	-17.84	-46.25	-80.29	-112.46	-142.56	-169.93	-199.04	-96.05
Percent difference	0.00%	-0.06%	-0.14%	-0.24%	-0.33%	-0.41%	-0.49%	-0.55%	-0.29%

Table 4. Comparison of deterministic net imports of major importing countries, with and without government payments

Variables	2013	2014	2015	2016	2017	2018	2019	2020	Average
Philippines				Thousand Metric Tons					
With government payments	2,626	2,808	3,037	3,123	3,207	3,407	3,658	3,985	3,231.51
Without government payments	2,626	2,807	3,033	3,116	3,196	3,394	3,643	3,967	3,222.74
Level difference	0.00	-1.61	-4.37	-7.40	-10.16	-12.99	-15.36	-18.29	-8.77
Percent difference	0.00%	-0.06%	-0.14%	-0.24%	-0.32%	-0.38%	-0.42%	-0.46%	-0.27%
Nigeria									
With government payments	2,251	2,386	2,327	2,328	2,291	2,311	2,308	2,316	2,314.79
Without government payments	2,251	2,385	2,325	2,325	2,287	2,306	2,302	2,310	2,311.47
Level difference	0.00	-0.67	-1.72	-2.93	-3.99	-4.96	-5.75	-6.55	-3.32
Percent difference	0.00%	-0.03%	-0.07%	-0.13%	-0.17%	-0.21%	-0.25%	-0.28%	-0.14%
Bangladesh									
With government payments	1,336	1,389	1,597	1,854	1,807	2,050	2,175	2,256	1,808.08
Without government payments	1,336	1,389	1,596	1,850	1,800	2,040	2,162	2,240	1,801.76
Level difference	0.00	-0.02	-1.23	-3.58	-6.69	-9.88	-13.20	-15.92	-6.31
Percent difference	0.00%	0.00%	-0.08%	-0.19%	-0.37%	-0.48%	-0.61%	-0.71%	-0.35%
Indonesia									
With government payments	1,275	1,311	1,453	1,387	1,526	1,512	1,668	1,976	1,513.48
Without government payments	1,275	1,307	1,440	1,363	1,492	1,468	1,617	1,918	1,485.05
Level difference	0.00	-4.54	-13.12	-24.38	-34.39	-43.20	-50.54	-57.25	-28.43
Percent difference	0.00%	-0.35%	-0.90%	-1.76%	-2.25%	-2.86%	-3.03%	-2.90%	-1.88%

Table 5a. Stochastic outcome distribution for international rice price, with government payments

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Average
					U.S. Dollars per Metric Ton						
Deterministic Baseline	491	492	505	515	528	542	538	562	566	588	533
Stochastic Average	491	492	506	515	528	542	535	558	562	581	531
Difference	0.01%	-.02%	0.26%	0.12%	-0.11%	-0.14%	-0.45%	-.56%	-0.71%	-1.06%	-0.27%
Standard Deviation	56	54	64	69	74	76	72	73	71	72	68
Percentiles											
5%	419	415	418	423	428	437	434	454	457	474	436
10%	432	432	439	441	447	458	453	474	478	499	455
20%	450	449	453	459	466	478	474	496	502	520	475
30%	459	459	469	473	482	494	490	513	519	540	490
40%	469	472	483	489	500	514	511	534	538	558	507
50%	479	482	494	504	517	529	525	549	553	573	521
60%	494	496	509	517	531	546	540	563	567	588	535
70%	511	512	527	541	556	572	565	589	593	613	558
80%	532	532	554	567	581	598	590	615	617	639	582
90%	568	561	592	609	629	646	634	656	656	677	623
95%	592	592	626	641	663	680	668	695	695	714	656

Table 5b. Stochastic outcome distribution for international rice price, without government payments

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Average
					U.S. Dollars Per Metric Ton						
Deterministic Baseline	491	492	505	515	529	544	540	565	569	592	534
Stochastic Average	491	493	508	518	531	546	540	564	567	588	534
Difference	0.01%	0.24%	0.59%	0.46%	0.25%	0.22%	-0.11%	-0.22%	-0.38%	-0.73%	0.03%
Standard Deviation	56	54	64	69	74	76	72	73	71	72	68
Percentiles											
5%	419	419	422	425	430	440	437	457	461	480	439
10%	432	433	439	442	448	460	455	477	483	503	457
20%	448	450	454	461	468	481	477	501	506	525	477
30%	458	461	471	476	487	499	495	521	527	548	494
40%	469	473	484	491	503	518	515	539	544	564	510
50%	480	483	496	505	519	532	529	554	558	580	524
60%	495	498	510	519	533	551	545	570	573	594	539
70%	513	514	529	542	558	575	570	594	598	619	561
80%	535	532	557	571	588	606	597	625	627	646	589
90%	571	564	595	614	633	650	639	664	663	684	628
95%	592	589	625	641	662	679	667	695	696	718	656

Table 6a. Stochastic outcome distribution for U.S. rice average farm price, with government payments

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Average
					U.S. Dollars per Cwt (rough basis)						
Deterministic Baseline	12.89	12.44	12.79	12.63	12.56	12.10	12.83	12.50	11.98	11.92	12.46
Stochastic Average	12.89	12.42	12.81	12.63	12.49	12.06	12.74	12.46	11.94	11.84	12.43
Difference	0.02%	-.20%	0.17%	0.05%	-0.52%	-0.40%	-0.77%	-.31%	-0.38%	-0.69%	-0.30%
Standard Deviation	1.06	0.99	1.14	1.18	1.21	1.22	1.17	1.15	1.09	1.08	1.13
Percentiles											
5%	11.31	11.05	11.22	10.95	10.75	10.29	10.99	10.76	10.31	10.22	10.79
10%	11.60	11.20	11.44	11.25	11.08	10.63	11.36	11.08	10.61	10.53	11.08
20%	12.00	11.59	11.87	11.68	11.54	11.10	11.82	11.53	11.00	10.90	11.50
30%	12.31	11.86	12.17	11.97	11.79	11.36	12.07	11.83	11.33	11.23	11.79
40%	12.54	12.12	12.40	12.24	12.07	11.64	12.34	12.08	11.59	11.51	12.05
50%	12.80	12.31	12.72	12.53	12.38	11.95	12.63	12.37	11.87	11.77	12.33
60%	13.01	12.60	13.01	12.79	12.64	12.21	12.90	12.65	12.15	12.07	12.60
70%	13.39	12.85	13.27	13.11	12.98	12.56	13.24	12.95	12.38	12.30	12.90
80%	13.77	13.21	13.67	13.52	13.45	13.05	13.72	13.48	12.88	12.75	13.35
90%	14.20	13.65	14.29	14.20	14.08	13.65	14.26	13.94	13.33	13.23	13.88
95%	14.60	14.18	15.00	14.80	14.75	14.33	14.86	14.56	13.88	13.77	14.47

Table 6b. Stochastic outcome distribution for U.S. rice average farm price, without government payments

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Average
					U.S. Dollars per Cwt (rough basis)						
Deterministic Baseline	12.89	12.44	12.79	12.61	12.52	12.05	12.76	12.46	11.93	11.88	12.43
Stochastic Average	12.89	12.44	12.84	12.65	12.49	12.03	12.70	12.42	11.89	11.80	12.42
Difference	0.05%	-.03%	0.39%	0.29%	-0.26%	-0.13%	-0.45%	-.32%	-.33%	-0.67%	-0.15%
Standard Deviation	1.04	0.99	1.16	1.19	1.22	1.23	1.18	1.16	1.10	1.09	1.14
Percentiles											
5%	11.35	11.04	11.16	10.94	10.73	10.23	10.94	10.69	10.25	10.12	10.75
10%	11.60	11.20	11.44	11.23	11.05	10.58	11.30	11.04	10.55	10.47	11.05
20%	12.00	11.62	11.88	11.68	11.52	11.08	11.77	11.49	10.95	10.86	11.49
30%	12.32	11.89	12.20	11.98	11.80	11.33	12.02	11.79	11.28	11.20	11.78
40%	12.56	12.16	12.43	12.24	12.05	11.62	12.30	12.02	11.54	11.48	12.04
50%	12.78	12.36	12.74	12.54	12.37	11.91	12.59	12.32	11.84	11.73	12.32
60%	13.02	12.60	13.03	12.79	12.65	12.16	12.87	12.60	12.09	12.02	12.58
70%	13.41	12.86	13.30	13.14	12.95	12.50	13.17	12.89	12.35	12.26	12.88
80%	13.80	13.21	13.75	13.64	13.46	13.04	13.70	13.43	12.85	12.71	13.36
90%	14.20	13.65	14.39	14.26	14.16	13.73	14.33	13.99	13.35	13.19	13.93
95%	14.56	14.19	15.00	14.82	14.73	14.28	14.80	14.50	13.80	13.70	14.44

Table 7. Eight-year (2013-2020) average changes in the 10th and 90th percentiles and gap between the two values (with and without government payments)

Variables	Unit	10th Percentile				90th Percentile				Gap between 10th and 90th Percentiles			
		With	Without	Change	%	With	Without	Change	%	With	Without	Change	%
Rice Prices:													
International Rice Price	$/MT	461.2	463.4	2.2	0.5%	637.2	642.8	5.6	0.9%	176.0	179.5	3.5	2.0%
U.S. Long Grain Export Price	$/MT	493.6	484.3	-9.3	-1.9%	629.0	622.6	-6.5	-1.0%	135.4	138.3	2.8	2.1%
U.S. Medium Grain Export Price	$/MT	672.1	671.1	-1.0	-0.1%	909.4	908.4	-1.0	-0.1%	237.2	237.2	0.0	0.0%
U.S. Average Farm Price	$/Cwt	11.0	11.1	0.1	0.6%	13.9	14.0	0.2	1.2%	2.9	3.0	0.1	3.5%
U.S. Rice (rough basis):													
U.S. Area Harvested	1000 Ac	3036.4	2925.5	-111.0	-3.7%	3436.9	3342.2	-94.7	-2.8%	400.4	416.7	16.3	4.1%
U.S. Rough Production	Mil. Cwt	226.1	218.6	-7.4	-3.3%	262.7	253.5	-9.2	-3.5%	36.6	34.9	-1.7	-4.7%
U.S. Domestic Consumption	Mil. Cwt	128.0	127.1	-0.9	-0.7%	137.9	136.2	-1.7	-1.2%	9.9	9.1	-0.8	-8.3%
U.S. Net Exports	Mil. Cwt	92.0	86.8	-5.2	-5.7%	120.7	117.0	-3.7	-3.1%	28.7	30.2	1.5	5.3%
Major Rice Countries & World:													
Thailand Net Exports	1000 MT	10309.6	10309.2	-0.4	0.0%	11779.5	11796.9	17.4	0.1%	1469.9	1487.7	17.8	1.2%
Vietnam Net Exports	1000 MT	5524.4	5516.4	-7.9	-0.1%	7275.4	7311.9	36.5	0.5%	1751.1	1795.5	44.5	2.5%
India Net Exports	1000 MT	-3929.0	-4124.2	-195.2	5.0%	8984.7	8907.6	-77.0	-0.9%	12913.7	13031.8	118.1	0.9%
Pakistan Net Exports	1000 MT	2771.4	2747.8	-23.7	-0.9%	4386.8	4406.1	19.3	0.4%	1615.4	1658.3	42.9	2.7%
World Net Trade	1000 MT	28455.9	28352.2	-103.7	-0.4%	37769.2	37752.6	-16.6	0.0%	9313.3	9400.4	87.1	0.9%
Philippine Net Imports	1000 MT	2513.3	2504.1	-9.2	-0.4%	4122.1	4123.7	1.6	0.0%	1608.8	1619.6	10.8	0.7%
Nigeria Net Imports	1000 MT	1910.0	1917.7	7.7	0.4%	2777.4	2771.7	-5.6	-0.2%	867.4	854.0	-13.4	-1.5%
Bangladesh Net Imports	1000 MT	-159.4	-120.8	38.7	-24.3%	3773.5	3762.9	-10.6	-0.3%	3933.0	3883.7	-49.3	-1.3%
Indonesia Net Imports	1000 MT	256.6	194.7	-61.9	-24.1%	3068.5	3083.3	14.8	0.5%	2811.9	2888.6	76.7	2.7%

Figure 1. International Reference Rice Price (with and without government payments)

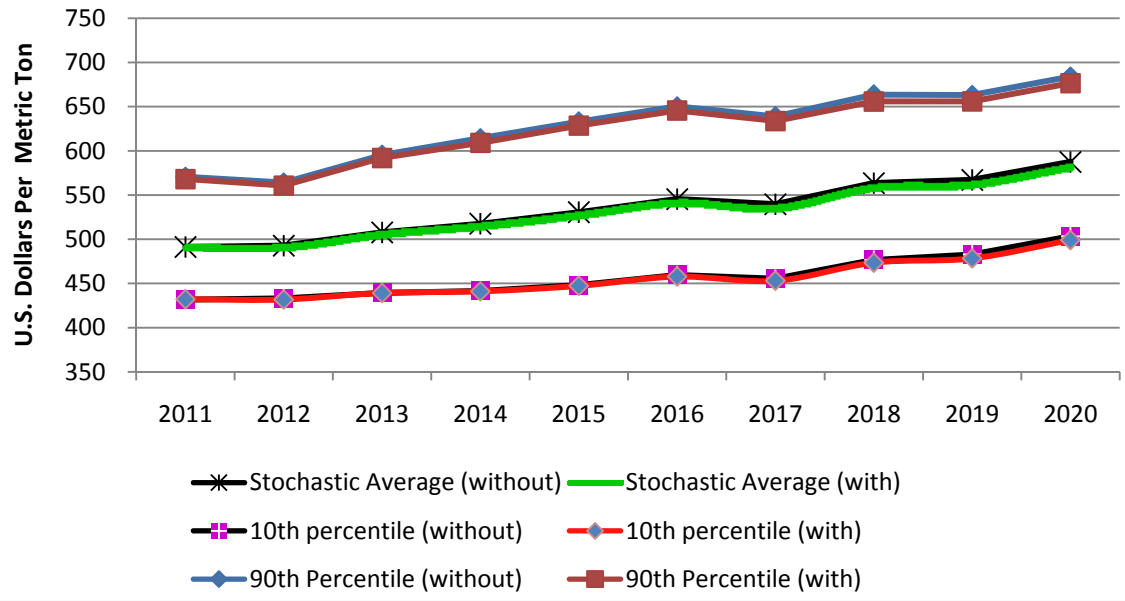

Figure 2. U.S. Rice Average Farm Price (with and without government payments)

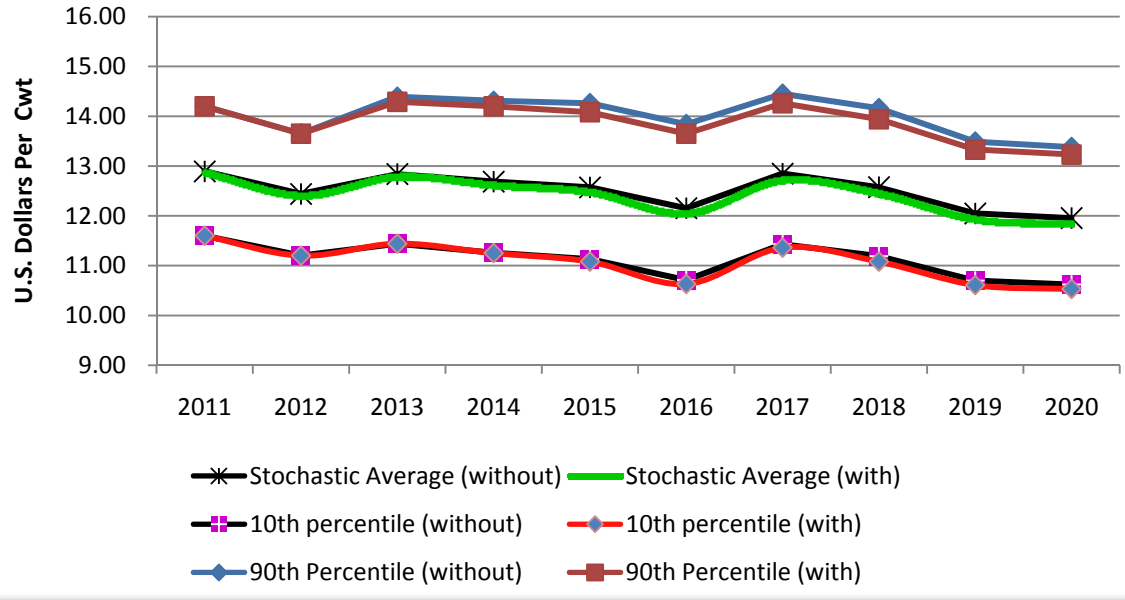

Figure 3. U.S. Rice Area Harvested (with and without government payments)

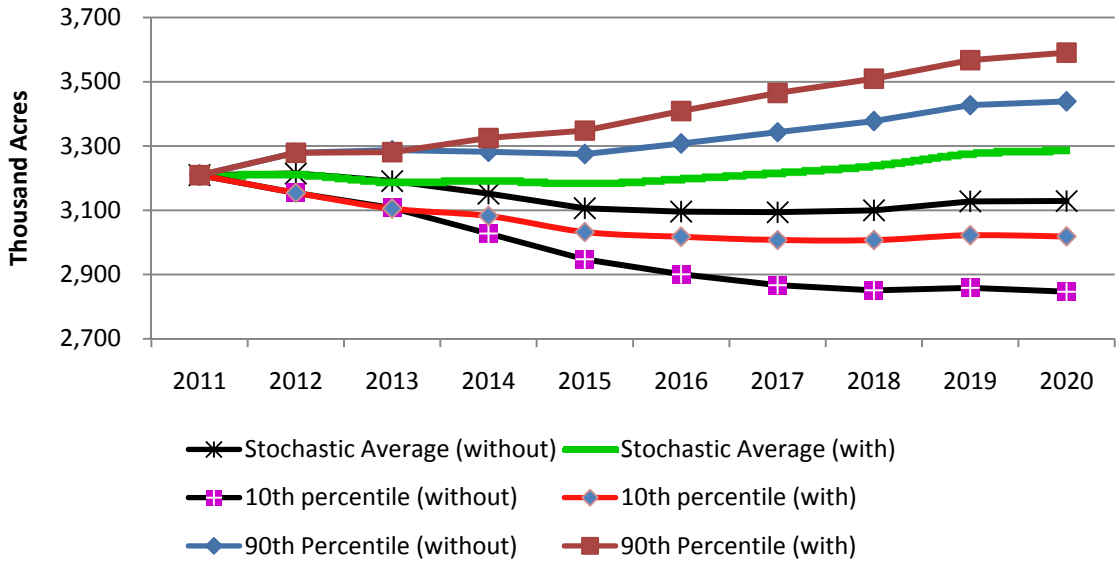

Figure 4. U. S. Net Rice Exports (with and without government payments)

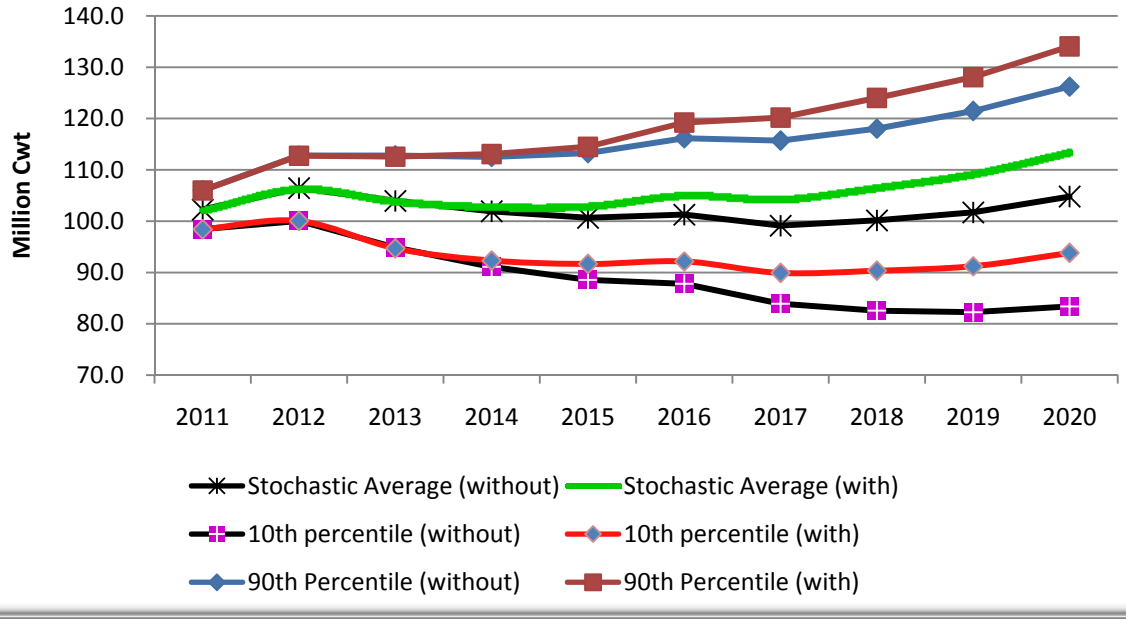

Figure 5. Vietnam Net Rice Exports (with and without government payments)

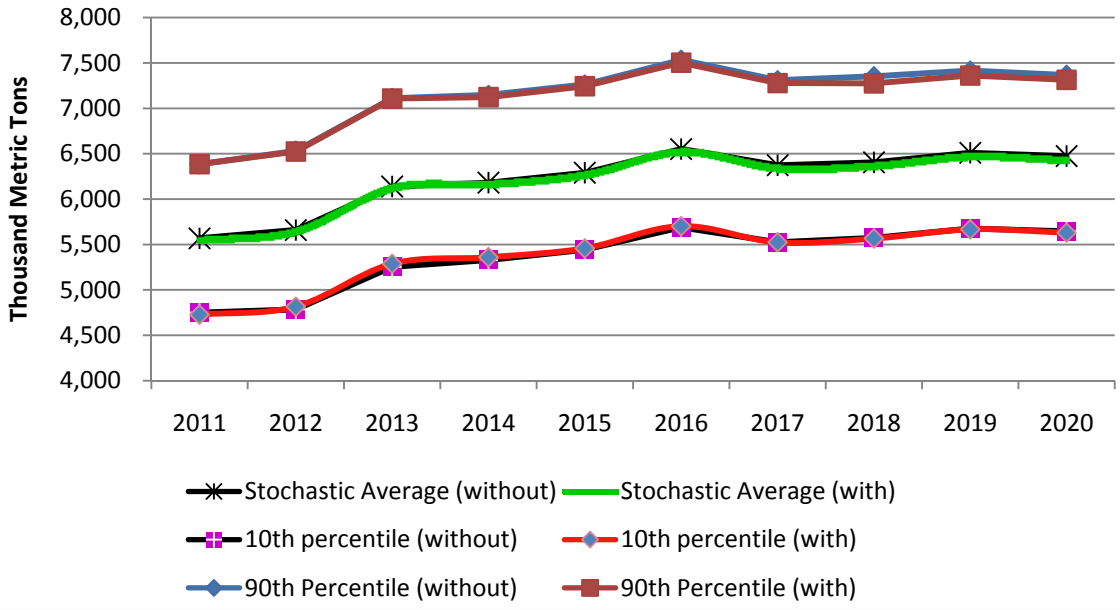

Figure 6. Indonesian Net Rice Imports (with and without government payments)

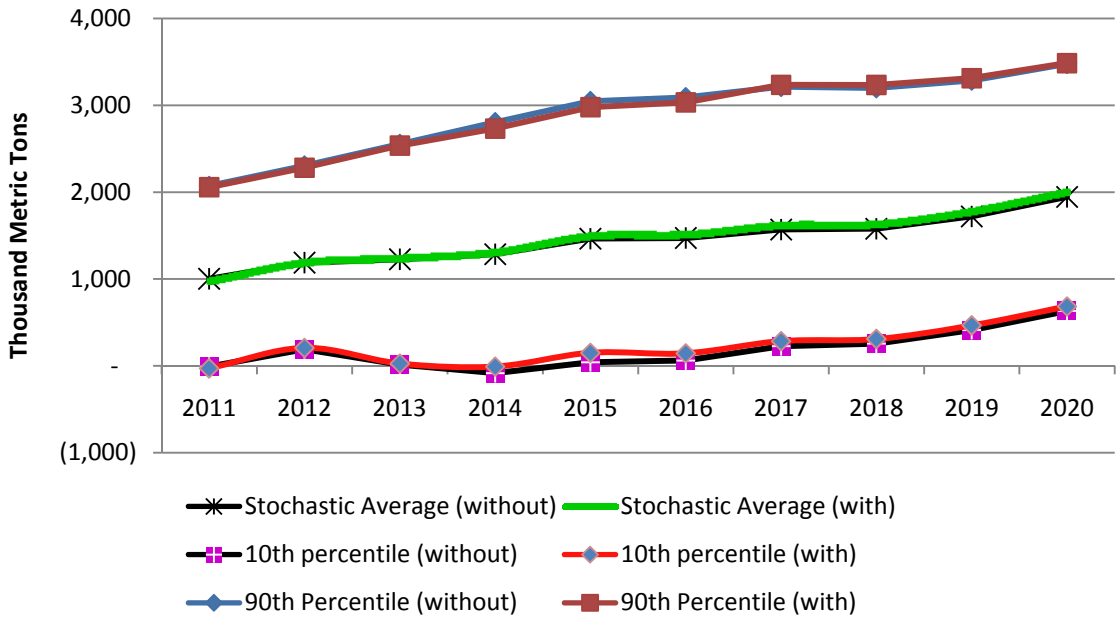

Figure 7. PDF Approximation

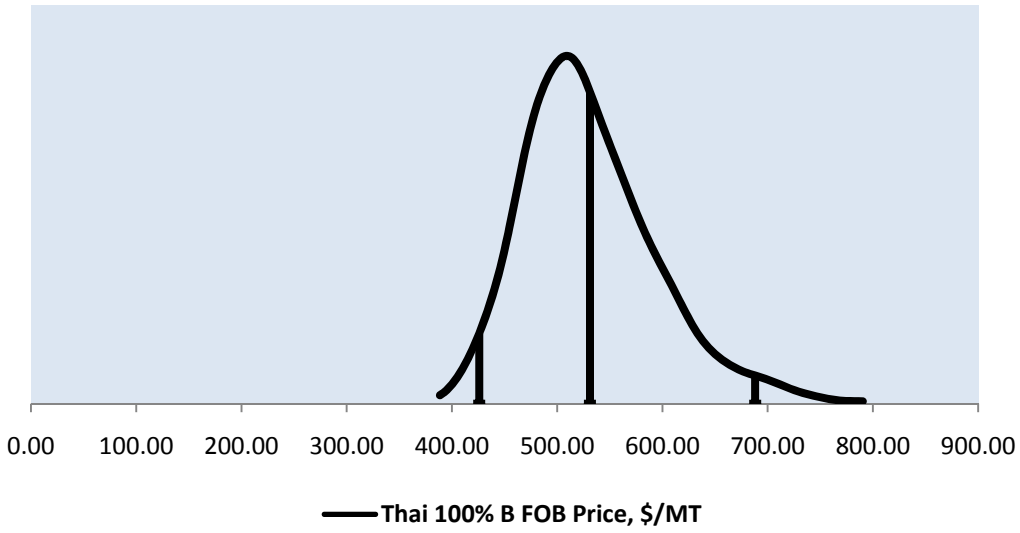

Figure 8. PDF Approximation

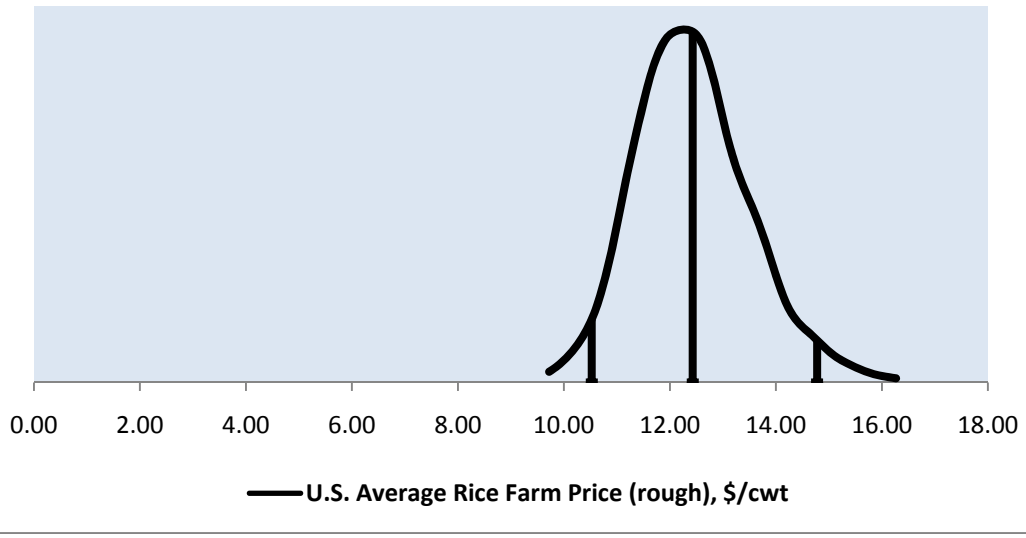

Figure 9. PDF Approximation

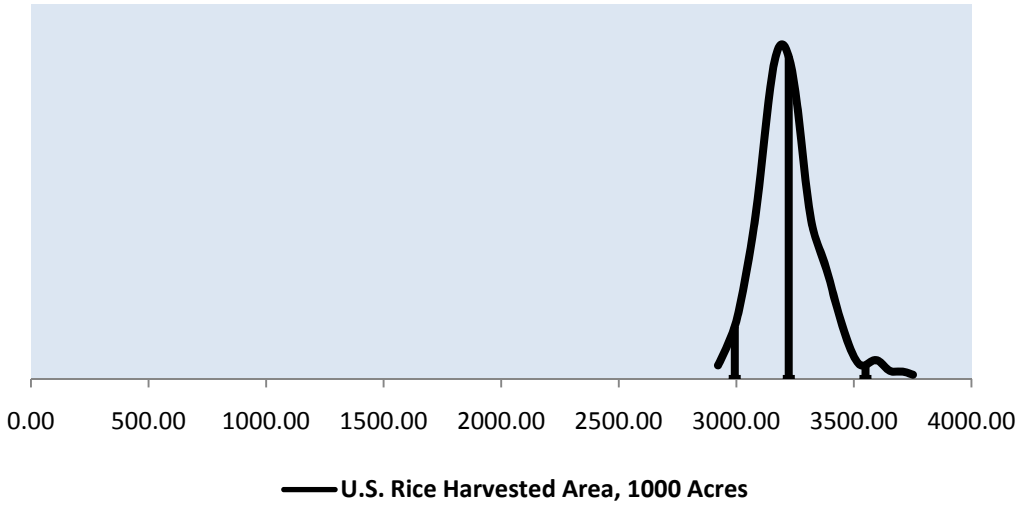

Figure 10. PDF Approximation

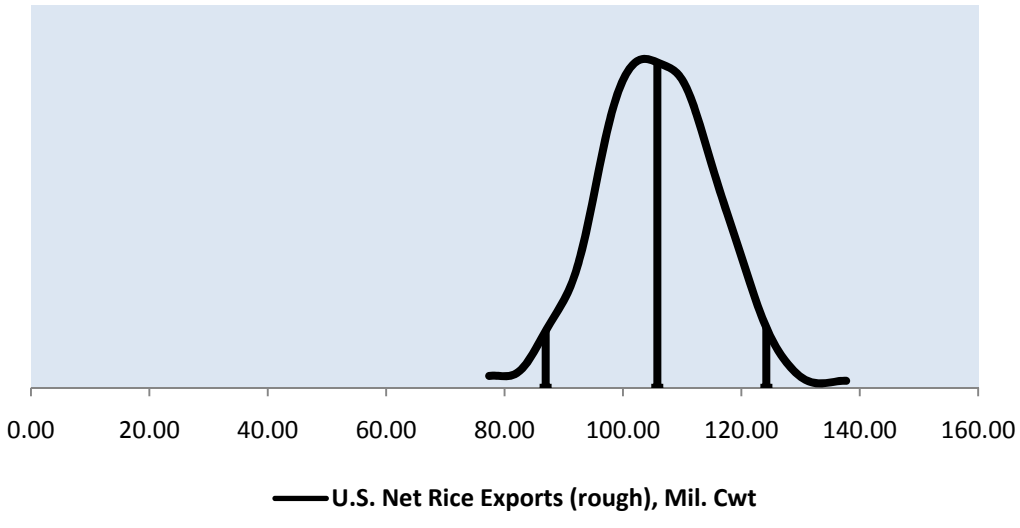

Figure 11. PDF Approximation

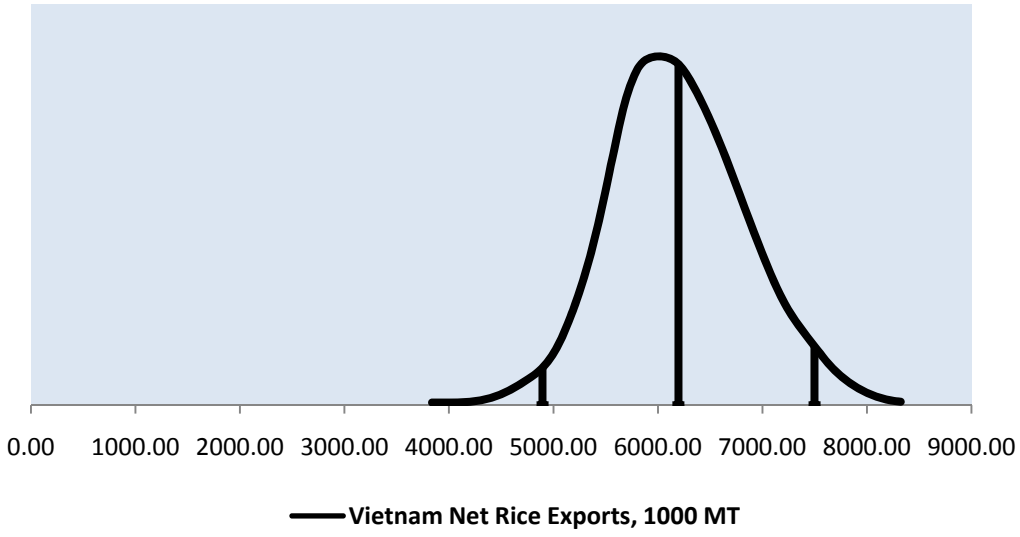

Figure 12. PDF Approximation