U.S. MARKET POTENTIAL FOR DRIED DISTILLERS GRAIN WITH SOLUBLES[a]

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Abstract

Prior research presumes that the U.S. livestock feed demand for dried distillers grains with solubles (DDGS) can accommodate the rapid growth in DDGS production. The objective of this work is to reexamine the market potential for DDGS by considering factors that limit the adoption rate of DDGS. An estimate of DDGS market size requires information about DDGS inclusion rates, animal populations, and adoption rates.

The rapid expansion of the ethanol industry will saturate the dairy and hog markets for DDGS by the end of 2009, while the beef and poultry use must triple to consume all available product. One must be circumspect of these forecasts for three reasons. First, the supply of DDGS is contingent on ethanol production. If the downturn in ethanol profitability spreads, less DDGS may be available to absorb. Second, in the short run, farms capable of consuming DDGS are not likely to shift, and thus animal populations are relatively fixed. However, the DDGS inclusion rates will most likely increase from current practices. Yet it is hard to imagine the market penetration rate will reach 100 percent for any class of livestock. Finally, export markets may also consume more DDGS than expected, reducing the pressure to expand US consumption. Thus, producers and consumer of DDGS would be well advised to pay careful attention to market developments as the US DDGS continues to grow.

Keywords: Market potential, distillers grains, livestock

JEL codes: Q10, Q13

Background

In 2008, ethanol production continued its rapid expansion in capacity that began in 2002. The US Department of Energy forecasts 2009 ethanol production will reach 11 billion gallons, up from 2.1 billion gallons in 2002 (Energy Information Administration, 2008). Additional expansion is possible because the renewable fuels standards of the Energy Independence and Security Act of 2007 mandates the use of 15 billion gallons of starch based (largely to come from corn) ethanol by 2015. As a co-product of ethanol, distillers grain production tracks the explosive growth in ethanol capacity, with projected production reaching as much as 40 million tons by 2009 (Togkoz et al., 2007).

Ethanol can be produced by either wet or dry grind corn milling. The interest of this analysis is limited to dry grind corn milling because wet corn mills have different co-products. Broadly referred to as distillers grains, co-products of a dry grind corn mill vary in their dry matter content and presence of solubles. Common forms of distillers grains include wet distillers grains with solubles (WDGS), dried distillers grains with solubles (DDGS), and modified distillers wet cake. The dry matter content ranges from 30 to 35 percent for WDGS to roughly 50 percent for wet cake to 90 percent for DDGS. In this work, all distillers grains marketed to the livestock industry are referred to simply as DDGS.

Previous estimates of the U.S. annual market size for DDGS range from 37 to 64 million tons. Cooper (2005) pegged the theoretical U.S. market for DDGS at 42 million tons. Using the FAPRI model, Togkoz et al. (2007) estimated a baseline demand of 37.3 million tons of DDGS, rising to as much as 63.7 million tons. Neither of these studies provided much background as to how the estimate was reached. Three other studies provided great detail on how DDGS market potential was estimated. Dhuyvetter et al. (2005), N'Guessan (2007), and Berger and Good (2007) used similar approaches to estimate DDGS market size by class of livestock (Table 1). These estimates ranged from 51.4 to 60.9 million tons. Dairy, all cattle, all swine, and all poultry account for 12.7, 66.4, 7.3, and 13.6 percent of DDGS market potential, respectively.

All of these works implicitly presume that the U.S. livestock market for DDGS can accommodate the rapid growth in DDGS production. E.g., Berger and Good (2007) note that 43 million tons of DDGS production would be "well below the amount of DDGS that conceptually could be incorporated into the feed rations of the current U.S. livestock and poultry industry" and "that domestic supplies of DDGS should not be burdensome in the near future." However, Cooper (2005) and Togkoz et al. (2007) note that the DDGS market penetration rate will not reach 100 percent. In short, not all farms will feed DDGS as part of their animal diets. Thus, the objective of this work is to reexamine the market potential for DDGS by considering factors that limit the adoption rate of DDGS.

An estimate of DDGS market size requires information about DDGS inclusion rates, animal populations, and adoption rates. Adoption of DDGS is most likely to occur on larger sized farms. The organization of this report is to detail the assumptions made for the three types of information, reviewing the literature and data sources for each. First, DDGS inclusion rates are obtained to estimate the potential consumption of DDGS by different classes of livestock. Second, N'Guessan's (2007) values for herd numbers for 10 classes of livestock and poultry obtained from the 2002 Census of Agriculture are updated to more recent data, based upon

Table 1. Estimates of DDGS Market Potential, by Livestock Class and Consensus Estimate

Study Year	Dhuyvetter et al. 2005	N'Guessan 2007	Berger & Good 2007	Market share
Livestock Class	Million tons			%
Dairy Cows	6.92	6.92	7.47	12.7
Beef Cows	10.81	10.82	11.97	20.1
Other Cattle	8.14	9.93	13.67	19.0
Cattle on Feed	13.52	15.12	17.03	27.3
All Cattle	32.47	35.87	42.67	66.4
Breeding Swine	1.14	1.14	1.14	2.0
Market Swine	2.90	2.92	3.08	5.3
All Swine	4.04	4.06	4.22	7.3
Broilers	4.95	5.10	4.70	8.8
Layers	2.01	1.99	1.86	3.5
Pullets	0.18	0.17	na	0.2
Turkeys	0.86	0.90	na	1.1
All Poultry	8.00	8.16	6.56	13.6
Total	51.43	55.01	60.92	100.0

National Agricultural Statistics Service (NASS) data. Third, assumptions are developed about the characteristics of farm sizes consuming DDGS. Finally, this information is combined to estimate the U.S. market size in 2009 for DDGS, providing both a likely estimate and the maximum amount that might be consumed, as well as how much inclusion rates must grow in the 2009 to utilize the likely production of 37.3 million tons.

DDGS Inclusion Rates

The first step to estimating DDGS market potential is to estimate how much DDGS is consumed as part of an animal's ration. Berger and Good (2007) summarized the literature for DDGS consumption for dairy, cattle, hogs, and poultry. Obviously, the most economical DDGS component of any ration will vary depending upon DDGS and other feedstock prices, nutrient composition, and availability. Dhuyvetter et al. (2005) and Berger and Good both provided assumed daily feeding rates and days on feed to arrive at annual levels of DDGS consumption per head (Table 2). Berger and Good's feeding rates are 8 to 26 percent higher for dairy and beef than Dhuyvetter et al. (2005), but very similar for swine and poultry. Days on feed only differ for other cattle, at 135 days for Dhuyvetter et al. and 180 days for Berger and Good.

Berger and Good's (2007) inclusion rates are validated by comparing them against two other studies. First, based on email correspondence with Berger (2008), percentage inclusion rates are provided for Berger and Good's assumed DDGS feeding rates (Table 3). These rates are then compared to maximum inclusion rates as summarized by the National Corn Growers

Table 2. Daily DDGS Feeding Rates, Days on Feed, and Annual DDGS, by Class of Livestock

Study	Dhuyvetter et al.			Berger & Good		
Class of Livestock	Daily DDGS (lbs/ day/ head)	Days on Feed	Annual DDGS/head (lbs/yr/head)	Daily DDGS (lbs/ day/ head)	Days on Feed	Annual DDGS/head (lbs/yr/head)
Dairy Cows	4.17	365	1,520.80	4.50	365	1,642.50
Beef Cows	7.22	90	650.00	8.00	90	720.00
Other Cattle	2.78	135	375.00	3.50	180	630.00
Cattle on Feed	5.56	365	2,027.80	7.00	365	2,555.00
Breeding Swine	1.21	310	374.00	1.20	310	372.00
Market Swine	0.47	365	171.60	0.50	365	182.50
Broilers	0.0207	56	1.16	0.02	56	1.12
Layers	0.0325	365	11.87	0.03	365	10.95
Pullets	0.0099	365	3.63	na	na	na
Turkeys	0.0421	151	6.35	na	na	na

Table 3. Percentage Inclusion Rates of DDGS in Livestock Diets, by Class of Livestock

Study	Berger & Good	National Corn Growers Assn.
Class of Livestock	Inclusion rate (%)	
Dairy Cows	15%	20%
Beef Cows	5%	10-20%
Other Cattle	20%	10-20%
Cattle on Feed	20%	na
Breeding Swine	15%	20%
Market Swine	15%	20%
Broilers	5%	10%
Layers	10%	15%
Pullets	na	na
Turkeys	na	10-20%

Association (2008), who summarized studies for different classes of livestock. Berger and Good's inclusion rates are less than the maximum values reported by the National Corn Growers Association. Thus, Berger and Goods inclusion rates are judged to be reasonable values given current technology for approximating upper limits of DDGS market potential. If anything, the market potential is somewhat larger, especially for beef cows.

Second, a NASS (2007) report provides summary information about actual livestock feeding practices based on a survey of 9,400 Midwest operations. Of these farms, 1,276 reported feeding ethanol co-products to dairy cattle, beef cattle, cattle on feed, or hogs. Results suggest that farmers' use of DDGS is below recommended levels. Inclusion rates are closest to Berger and Good's (2007) recommendations for dairy cattle, at 1,002 pounds instead of 1,642 pounds (Table 4). Cattle on feed consume the second most pounds per head at 916, but this is only 36 percent of the potential. Beef cattle are fed 55 percent of the potential 720 pounds of DDGS per year, while hogs are fed only 60 of a possible 211 pounds per head per year.

Table 4. Comparison of Recommended and Actual DDGS Inclusion Rates, 2007

Class of livestock	Potential Inclusion Rate (Berger and Good)	Actual Inclusion Rate (NASS)[1]	Actual as a Percent of Potential Inclusion Rate
Dairy	1,642.5	1,002	61.0%
Beef	720.0	396	55.0%
Cattle on Feed	2,555.0	916	35.9%
Hogs	211.5	60	28.4%

[1]National Agricultural Statistics Service, 2007.

Berger and Good's (2007) inclusion rates are more recent than Dhuyvetter et al. (2005) and thus are used in this analysis to establish the upper limit on market potential for DDGS. The inclusion rate for pullets and turkeys come from Dhuyvetter et al. because Berger and Good did not provide an estimate for these classes of livestock. The NASS inclusion rates will be used as the current limit with the following adjustments for missing classes of livestock. Other cattle are assumed to be fed at the same percentage rate as beef cattle. Per N'Guessan (2007), all classes of poultry are assumed to be fed at the same rates as hogs, or 28.4 percent.

Animal Populations

Estimates of animal populations began with the values used by N'Guessan (2007). His work is based on USDA 2002 Census of Agriculture data for 10 classes of animals (dairy, beef, cattle on feed, other cattle, breeding and market swine, broilers, layers, pullets, and turkeys) (Table 5). The growth of the ethanol industry and the resulting availability of DDGS in the Corn Belt may influence state level populations for cattle on feed, dairy cattle, and hogs (Berger and Good (2007). Thus, animal populations are updated to the most recent data available from various NASS reports (Table 5). Animal populations have been generally flat over the past five years, except for market swine (up 15.9 percent) and pullets (up 7.4 percent).

Table 5. Herd Size, by Class of Livestock, and Year

Class of Livestock	US Herd Population 2002[1] (million)	US Herd Population 2007 (million)	Percent Change from 2002 to 2007
Dairy Cows	9.096	9.297[a]	2.2%
Beef Cows	33.310	32.519[a]	-2.4%
Other Cattle	52.925	54.735[a]	3.4%
Cattle on Feed	14.903	14.317[a]	-3.9%
Breeding Swine	6.053	6.219[b]	2.7%
Market Swine	33.999	39.393[b]	15.9%
Broilers	8,499.582	8,899.903[c]	4.7%
Layers	333.780	344.007[d]	3.1%
Pullets	95.206	102.258[d]	7.4%
Turkeys	283.248	271.288[e]	-4.2%

[1] U.S. 2002 Census of Agriculture, based on N'Guessan (2007). U.S. inventory for all classes except broilers and turkeys which are annual U.S. production.

[a]USDA National Agricultural Statistics Service. Quick Stats: U.S. & All States Data - Cattle & Calves. http://www.nass.usda.gov/QuickStats/Create_Federal_All.jsp

[b]USDA National Agricultural Statistics Service. Quick Stats: U.S. & All States Data - Hogs & Pigs. http://www.nass.usda.gov/QuickStats/Create_Federal_All.jsp

[c]USDA National Agricultural Statistics Service. 2008. Poultry - Production and Value 2007 Summary. Pou 3-1 (08). http://usda.mannlib.cornell.edu/usda/current/PoulProdVa/PoulProdVa-04-28-2008.pdf

[d]USDA National Agricultural Statistics Service. 2008. Chickens and Eggs 2007 Summary. Pou 2-4 (08). http://usda.mannlib.cornell.edu/usda/current/ChickEgg/ChickEgg-02-28-2008.pdf

[e]USDA National Agricultural Statistics Service. 2008. Turkeys Raised. http://usda.mannlib.cornell.edu/usda/current/TurkRaisSu/TurkRaisSu-08-25-2008.pdf

Farm Size and DDGS Consumption

As mentioned, not all farms will feed DDGS. The reasons for not consuming DDGS vary somewhat by class of livestock (Table 6). Lack of availability is the main reason for all classes, although this reason may diminish with the rapid expansion in ethanol capacity. Several of the disadvantages are more likely to occur on smaller farms, including infrastructure and handling, lack of knowledge, considers operation too small, transportation, and shelf life. Combined, perhaps 25 to 40 percent of the farms may find it difficult to feed DDGS because of their size.

Most likely the decision to feed DDGS is driven by how many days it will take to consume a truckload of DDGS, typically the smallest shipment size available from an ethanol plant. Using information from the same NASS (2007) report, it is possible to estimate on average how many days a truckload will last for dairy, cattle on feed, beef cattle, and hogs. After estimating how many days a truckload of DDGS will last, herd sizes supported per truckload are calculated for all classes of livestock. Herd size distributions are then analyzed to determine what proportion of the animal populations might be fed DDGS.

Table 6. Reasons for Not Feeding Ethanol Co-Products, by Class of Livestock, 2007

Reason for not feeding co-products	Dairy Cattle	Beef Cattle	Cattle on Feed	Hogs
	percent			
Availability	26	38	35	36
Infrastructure and handling	16	12	22	14
Cost	13	10	11	10
Nutrition	8	4	2	16
Raise own feed	10	9	5	3
Satisfied with current program	8	7	5	5
Lack of knowledge	5	5	5	5
Operation too small	0	5	4	3
Transportation	2	3	4	1
Shelf Life	2	2	5	1
Other	10	5	2	6
Total	100	100	100	100

SOURCE: National Agricultural Statistics Service, 2007.

The NASS (2007) information on average herd size consuming DDGS and actual daily DDGS consumption rates are multiplied to estimate pounds of DDGS consumed per day per farm (Table 7). A truckload of DDGS weighs 48,000 pounds. Dividing the truckload weight by daily farm consumption determines how many days farmers plan to use a truckload of DDGS. Thus, one truckload will last from 10 days for hogs to 64 days for dairy.

Table 7. Days Fed per Truckload of DDGS, by Livestock Class, 2007

Livestock class	Average Herd Size per Farm[1]	Daily DDGS Consumption (lbs/day)[1]	Pounds Consumed per Day per Farm	Days per Truckload of DDGS
Dairy	272	2.75	747	64
Beef	344	4.40	1,514	32
Cattle on Feed	1,590	1.29	2,053	23
Hogs	27,708	0.17	4,800	10

[1]National Agricultural Statistics Service, 2007.

Thus, a conservative assumption is that farmers feed a truckload of DDGS in 60 days, or at a rate of 800 pounds per day. The next step is to determine how many head are required per farm, by class of livestock, to consume that much feed per day. This calculation is done using Berger and Good's (2007) inclusion rate (Table 8). The results indicate how large a herd must be to consume a truck within 60 days. E.g., a dairy herd would need to have 178 cows, while it would take a flock of 80,527 pullets to eat a truckload of DDGS in two months.

Table 8. Average Herd Size to Consume a Truck of DDGS in 60 Days, by Livestock Class

Livestock Class	DDGS/Day/ Head (lbs/day/animal)	Herd Size/Truck per 60 days	Minimum Size Class to Consume DDGS	Percent of Animal Population Able to Consume DDGS[1]
Dairy Cows	4.500	178	Over 100 Head	77.2%
Beef Cows	8.000	100	Over 100 Head	53.7%
Other Cattle	3.500	229	Over 100 Head	78.2%
Cattle on Feed	7.000	114	All	100.0%
Breeding Swine	1.200	667	Over 1,000 Head	92.8%
Market Swine	0.500	1,600	Over 2,000 Head	88.0%
Broilers	0.0207	38,707	Over 45,000 Birds	79.4%
Layers	0.0325	24,592	Over 20,000 Birds	88.7%
Pullets	0.0099	80,527	Over 100,000 birds	62.1%
Turkeys	0.0421	19,012	Over 30,000 Birds	96.9%

[1] National Agricultural Statistics Service. 2008.

Distributions of herd sizes for dairy, cattle, and hogs are available from National Agricultural Statistics Service (2008), while distributions for poultry are taken from the 2002 Census of Agriculture. For example, distribution of dairy cows are reported by farm sizes: 1-29, 30-49, 50-99, 100-199, 200-499, 500-999, 1,000-1,999, and 2,000+ head per farm. The farm size categories vary by class of livestock (see Appendix A for distributions for all ten classes of livestock). The herd size per truckload from Table 8 sets a floor for farm size, and the percentage of animals in classes greater than that size is determined. For example, the herd size of 178 dairy cows per truckload means the herd sizes are sought for at least 100 cows. According to NASS data, 77.2 percent of the US dairy cattle are found on farms with 100 or more head. The proportion of livestock on farms big enough to consume a truckload of DDGS within two months ranges from 53.7 percent for beef cows to 100 percent for cattle on feed.

Market Size Potential for DDGS

The review of DDGS inclusion rates and animal populations establishes the assumptions used to estimate the potential market size for DDGS (see Table 9). The DDGS inclusion rates are the current practice which reflects actual inclusion rates reported by NASS (Table 4) or the recommended rate from Table 8. The populations are all animals by class from Table 5 or those values adjusted to only feed livestock found on larger sized farms (Table 8).

Combining the two inclusion rates with the two animal population sizes leads to four possible scenarios for DDGS consumption (Table 10). The distinction between animal populations leads to the assumptions that a scenario is classified as *likely* versus as a *theoretical limit*. The long term theoretical limit would be an estimate comparable to those by Berger and Good (2007) or Dhuyvetter et al. (2005). The scenario for Long Term Upper Limit tons in Table 1 simply because animal populations are larger (see Table 5). The scenario 2008 Upper Limit is of no practical relevance as many farms are not currently feeding DDGS. The scenario for 2008

Table 9. DDGS Inclusion Rates and Herd Populations, 2007

Class of Livestock	Annual DDGS Inclusion Rate (lbs/year/head)		Animal Population (million)	
	Current Practice (NASS)	Upper Limit (Berger and Good)	Large Farms Only	All Animals
Dairy Cows	1,002.00	1,642.50	7.178	9.297
Beef Cows	396.00	720.00	17.463	32.519
Other Cattle	346.50	630.00	42.802	54.735
Cattle on Feed	916.00	2,555.00	14.317	14.317
Breeding Swine	105.53	372.00	5.771	6.219
Market Swine	51.77	182.50	34.666	39.393
Broilers	0.33	1.1574	7,066.523	8,899.903
Layers	3.37	11.87	305.134	344.007
Pullets	1.03	3.63	63.502	102.258
Turkeys	1.80	6.35	262.878	271.288

Table 10. Estimates of DDGS Market Potential, for Four Scenarios

Scenario:	2008 Most Likely	Long Term Likely	2008 Upper Limit	Long Term Upper Limit
Class of Livestock	Inclusion Rate/Animal Population			
	Current Practice/ Large Farms	Upper Limit/ Large Farms	Current Practice/ All Animals	Upper Limit/ All Animals
	Million tons			
Dairy Cows	3.596	5.895	4.658	7.635
Beef Cows	3.458	6.287	6.439	11.707
Other Cattle	7.416	13.483	9.483	17.241
Cattle on Feed	6.557	18.290	6.557	18.290
Breeding Swine	0.305	1.073	0.328	1.157
Market Swine	0.897	3.163	1.020	3.595
Broilers	1.160	4.089	1.461	5.150
Layers	0.514	1.812	0.579	2.042
Pullets	0.033	0.115	0.053	0.185
Turkeys	0.237	0.835	0.245	0.862
Total US	24.172	55.041	30.822	67.865

Most Likely suggests that 24.2 million tons of DDGS will be consumed in 2008, with a current upper bound of 55 million tons (Long Term Likely scenario). The validity of this estimate is evaluated in the next section.

Market Penetration Rates

Cooper (2005) and the Renewable Fuels Association (2008) reported the distribution of DDGS consumption among beef, dairy, swine, and poultry for the years 2001 to 2007 (Table 11). Historically, cattle and dairy have consumed most of the DDGS on an annual basis, roughly 84 percent, while hogs consume around 11 percent, and poultry the remaining 5 percent.

Table 11. Calculation of DDGS Penetration Rates, by Class of Livestock, by Year

DATA AVAILABLE	Distribution of DDGS Consumption, by Class[1]						
Class of Livestock	2001	2002	2003	2004	2005	2006	2007
Dairy	60%	45%	46%	44%	45%	46%	42%
Cattle	36%	35%	39%	37%	37%	42%	42%
Swine	2%	15%	11%	16%	13%	9%	11%
Poultry	2%	5%	4%	3%	5%	3%	5%
Total	100%	100%	100%	100%	100%	100%	100%
	DDGS Available for Consumption (million tons)						
STEP 1	2001	2002	2003	2004	2005	2006	2007
Total Production[1]	3.42	3.97	6.39	8.05	9.92	13.23	16.09
Exports[2]	0.88	0.93	0.82	0.87	1.18	1.38	2.60
Net for Domestic Use	2.54	3.04	5.57	7.18	8.74	11.85	13.49
STEP 2	Tons of DDGS Consumed, By Class (million tons)						
Class of Livestock	2001	2002	2003	2004	2005	2006	2007
Dairy (max tons = 5.90)	1.52	1.37	2.56	3.16	3.93	5.45	5.67
Cattle (max tons = 38.06)	0.91	1.06	2.17	2.66	3.23	4.98	5.67
Swine (max tons = 4.24)	0.05	0.46	0.61	1.15	1.14	1.07	1.48
Poultry (max tons = 6.85)	0.05	0.15	0.22	0.22	0.44	0.36	0.67
STEP 3	Market Penetration for DDGS Consumption, By Class						
Class of Livestock	2001	2002	2003	2004	2005	2006	2007
Dairy	25.8%	23.2%	43.5%	53.6%	66.7%	92.5%	96.1%
Cattle	2.4%	2.8%	5.7%	7.0%	8.5%	13.1%	14.9%
Swine	1.2%	10.8%	14.5%	27.1%	26.8%	25.2%	35.0%
Poultry	0.7%	2.2%	3.3%	3.1%	6.4%	5.2%	9.8%

[1] Renewable Fuels Association. 2008.
[2] http://www.ers.usda.gov/data/feedgrains/FeedGrainsQueriable.aspx.

Using these values, one is able to calculate the tonnage of DDGS consumed by class of livestock following a three step process. First, the Renewable Fuels Association (2008) also reports annual production levels of DDGS from 2001 to 2007, with production increasing from

3.4 to 16.1 million tons over that time span (Table 11). Exports are subtracted from production to arrive at net production available for domestic consumption. Export data for brewers or distillers spent grain are reported as part of the ERS's Feed Grains Database: Custom Queries, for the years 2001 to 2008. Over that time, exports have almost tripled, increasing from 0.88 to 2.60 million tons (Table 11).

The second step is to multiply the allocation of DDGS by net production available for domestic consumption, to arrive at the tons of DDGS consumed annually by dairy, cattle, swine, and poultry. For example, in 2007, dairy consumed 42 percent of the 13.49 million tons available for consumption (Table 11). This means that dairy, cattle, swine, and poultry consumed 5.67, 5.67, 1.48, and 0.67 million tons, respectively, in 2007.

The final step is to determine the market penetration among the different classes of livestock. Based on the current practice inclusion rates of DDGS in the diets of the respective classes of livestock (Table 10), the maximum tonnage of DDGS that can be consumed by dairy, cattle, swine, and poultry is assumed to be 5.90, 38.06, 4.24, and 6.85 million tons, respectively (Table 11). Dividing the estimated tons consumed from step 2 by the maximum tons that can be consumed provides an estimate of the market penetration rate, or the proportion of the animal population that is consuming DDGS.

In 2007, dairy almost reached its peak use of DDGS, with a market penetration rate of 96.1 percent (Table 11). This suggests there is little room for additional growth in DDGS consumption by dairies, unless inclusion rates increase or DDGS are fed to smaller dairy herds. The market penetration rate is 35.0 percent of the swine potential. In both cases, typical farms are quite large, allowing the operation to utilize truckload shipments of DDGS in the animal diets. In contrast, only 14.9 and 9.8 percent of potential consumption of DDGS was realized for cattle and poultry, respectively.

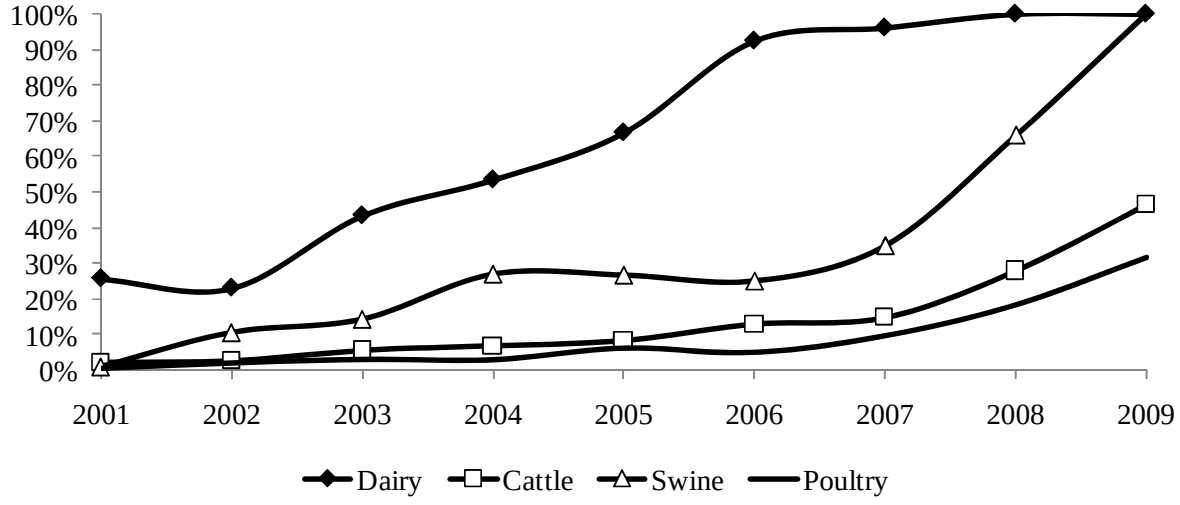
To complete the analysis, market penetration rates are forecast for 2008 and 2009, starting with estimated production and exports of DDGS. Based on estimates of ethanol production for 2008 and 2009, it is likely that 25.57 and 37.33 million tons of DDGS will be produced, respectively (Table 12). Estimated exports of DDGS for 2008 are 4.95 million tons and 7.30 million tons in 2009. Thus, the amount of DDGS available for consumption will rise sharply from 13.49 million tons in 2007 to 20.62 and 30.03 million tons in 2008 and 2009, respectively. Compared to 2007, this represents around a 50 percent growth rate in both 2008 and 2009.

The rapid expansion in DDGS availability presents short run challenges and opportunities for the livestock sector. Unless, exports rapidly expand, DDGS consumption can only increase if market penetration rates increase or inclusion rates increase. Assuming no increase in inclusion rates for dairy and hogs, these markets will be saturated by the end of 2009 (Figure 1). Growth in beef cattle consumption is the most likely path towards domestic consumption of the rapid expansion in DDGS availability. To meet this growth, beef consumption must expand threefold from 5.67 million tons in 2007 to 17.72 million tons in 2009. Similarly, poultry consumption will have to grow from 0.67 to 2.18 million tons.

Table 12. Forecast DDGS Penetration Rates for 2008 and 2009, by Class of Livestock, by Year

	DDGS Available for Consumption (million tons)		
STEP 1	2007	2008	2009
Total Production	16.09	25.57	37.33
Exports	2.60	4.95	7.360
Net for Domestic Use	13.49	20.62	30.03
STEP 2	Tons of DDGS Consumed, By Class (million tons)		
Class of Livestock	2007	2008	2009
Dairy (max tons = 5.90)	5.67	5.90	5.90
Cattle (max tons = 38.06)	5.67	10.66	17.72
Swine (max tons = 4.24)	1.48	2.79	4.24
Poultry (max tons = 6.85)	0.67	1.27	2.18
STEP 3	Market Penetration for DDGS Consumption, By Class		
Class of Livestock	2007	2008	2009
Dairy	96.1%	100.0%	100.0%
Cattle	14.9%	28.0%	46.6%
Swine	35.0%	65.9%	100.0%
Poultry	9.8%	18.5%	31.8%

Figure 1. DDGS Market Penetration Rates, 2001 to 2009



Conclusions

The rapid expansion of the ethanol industry will saturate the dairy and hog markets for DDGS by the end of 2009, while the beef and poultry use must triple to consume all available product. One must be circumspect of these forecasts for three reasons. First, the supply of DDGS is contingent on ethanol production. If the downturn in ethanol profitability spreads, less DDGS

may be available to absorb. Second, in the short run, farms capable of consuming DDGS are not likely to shift, and thus animal populations are relatively fixed. However, the DDGS inclusion rates will most likely grow from current practices as of 2007 reported by NASS to maximum inclusion rates as suggested by Berger and Good (2007). Yet it is hard to imagine the market penetration rate will reach 100 percent for any class of livestock. Finally, export markets may also consume more DDGS than expected, reducing the pressure to expand US consumption. Thus, producers and consumer of DDGS would be well advised to pay careful attention to market developments as the US DDGS continues to grow.

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Appendix A. Distribution of Livestock Population, by Herd Size, by Class

Livestock Class	Herd Size	Frequency	Cumulative Distribution
Dairy	1-29 head	1.7%	1.7%
	30-49 head	5.7%	7.4%
	50-99 head	15.4%	22.8%
	100-199 head	13.4%	36.2%
	200-499 head	14.9%	51.1%
	500-999 head	12.5%	63.6%
	1,000-1,999 head	13.3%	76.9%
	Over 2,000 head	23.1%	100.0%
Beef Cows	1-49 head	27.7%	27.7%
	50-99 head	18.6%	46.3%
	100-499 head	38.7%	85.0%
	500-999 head	8.0%	93.0%
	1,000-1,999 head	3.5%	96.5%
	2,000-4,999 head	2.2%	98.7%
	Over 5,000 head	1.3%	100.0%
Other Cattle	1-49 head	10.6%	10.6%
	50-99 head	11.2%	21.8%
	100-499 head	34.0%	55.8%
	500-999 head	12.8%	68.6%
	1,000-1,999 head	8.1%	76.7%
	2,000-4,999 head	8.3%	85.0%
	5,000-9,999 head	4.2%	89.2%
	10,000-19,999 head	3.2%	92.4%
	Over 20,000 head	7.6%	100.0%
Cattle on Feed	1-999 head	16.1%	16.1%
	1,000 - 3,999 head	9.1%	25.1%
	4,000 - 15,999 head	17.1%	42.3%
	16,000-31,999 head	17.7%	60.0%
	Over 32,000 head	40.0%	100.0%
Hogs	1-99 head	1.0%	1.0%
	100-499 head	3.0%	4.0%
	500-999 head	3.2%	7.2%
	1,000-1,999 head	4.8%	12.0%
	2,000-4,999 head	9.0%	21.0%
	5,000-9,999 head	8.0%	29.0%
	10,000-19,999 head	8.0%	37.0%
	20,000-49,999 head	9.0%	46.0%
	Over 50,000 head	54.0%	100.0%

Appendix A. Distribution of Livestock Population, by Herd Size, by Class

Livestock Class	Herd Size	Frequency	Cumulative Distribution
Broilers[1]	1-306 birds	0.0%	0.0%
	307-2,454 birds	0.0%	0.0%
	2,455-4,602 birds	0.1%	0.1%
	4,603-9,205 birds	0.2%	0.3%
	9,206-15,342 birds	1.0%	1.3%
	15,343-30,684 birds	5.9%	7.2%
	30,685-46,027 birds	13.4%	20.6%
	46,028-76,712 birds	25.8%	46.4%
	Over 76,712 birds	53.6%	100.0%
Layers	1-99 birds	0.1%	0.1%
	100-399 birds	0.1%	0.2%
	400-3,199 birds	0.2%	0.4%
	3,200-9,999 birds	2.2%	2.6%
	10,000-19,999 birds	8.8%	11.3%
	20,000-49,999 birds	12.8%	24.1%
	50,000-99,999 birds	10.7%	34.8%
	Over 100,000 birds	65.2%	100.0%
Pullets	1-1,999 birds	0.2%	0.2%
	2,000-15,999 birds	0.7%	0.8%
	16,000-29,999 birds	3.2%	4.0%
	30,000-59,999 birds	16.1%	20.2%
	60,000-99,999 birds	17.8%	37.9%
	Over 100,000 birds	62.1%	100.0%
Turkeys[1]	1-826 birds	0.1%	0.1%
	827-3,309 birds	0.2%	0.2%
	3,310-6,618 birds	0.5%	0.8%
	6,619-12,410 birds	2.3%	3.1%
	12,410-24,821 birds	12.0%	15.1%
	24,822-41,369 birds	19.7%	34.7%
	Over 41,370 birds	65.3%	100.0%

SOURCE: National Agricultural Statistics Service (2008) and United States Department of Agriculture. 2002.

[1]Number of birds sold for the broilers and turkeys were divided by 365/56 and 365/151, respectively, to arrive at number of cycles per year.