

Evaluation of sorting accuracy for market pigs

Evaluation of statistics used to quantify the magnitude of errors in sorting market pigs via simulation

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Introduction

Pork processors have established marketing grids in which carcasses heavier or lighter than a specified carcass weight range are discounted in value. To reduce sort loss, most commercial producers visually evaluate body weight of each pig to identify heaviest pigs for marketing on multiple marketing cuts. On larger farms, sorting crews target a specific number of heavy pigs in each pen to be marketed each day. In large pens, the sorting crew may identify the target number of pigs for marketing (i.e., 25%, 32 out of 125) before visually evaluating all pigs in the pen. Thus, two types of pig marketing errors exist: errors in the estimation of body weight for the pigs visually evaluated (BWEE) and the percentage of pigs that are not visually evaluated (PNVE).

Traditionally, sort loss has been used to estimate accuracy when pigs are sorted for marketing. However, many other factors can affect the accuracy of total sort loss per pig. A study was done to: (1) evaluate methods that quantify the magnitude of sorting errors for market pigs from currently available data, (2) estimate the impact of sorting errors on carcass weight average and variance, (3) demonstrate the impact that each of the two sorting errors has on the identified measures of sorting accuracy, and (4) evaluate the use of new statistical procedures with actual data.

Materials and Methods

Body weight growth curves for 4000-head wean-to-finish barns were simulated. A marketing strategy was simulated to represent what pork producers currently use. Twenty-five percent of the pigs were targeted to be marketed at 169 d, 25% at 179 d and the remaining pigs marketed at 193 d of age.

Four body weight assessment error rates (BWEE) were simulated to represent zero, low, average, and high levels of visual assessment of body weight accuracy with standard deviations of 0, 4, 6 and 8% of each pig's actual body weight. The percentage of pigs without visual body weight evaluation (PNVE) was 0, 8, 16 and 24%. These values are based on the inspection of carcass data obtained from several barns, with three marketing cuts per barn.

Several statistical models were estimated from simulated carcass weight data currently including date (used to estimate age at marketing), carcass weight, and sort loss. Sort loss was calculated using a market value system for a Midwestern U.S. pork processor (IPC, 2015, Table 1). The average and variance for body

Table 1. Carcass weight discount rates for different carcass weight classes.

Carcass weight, lb.	Discount, \$/cwt
<150.5	20.00
151-160.5	13.00
161-165.5	8.00
166-170.5	5.50
171-180.5	3.50
181-235.5	0.00
236-240.5	3.00
241-245.5	11.00
246-250.5	13.00
251-255.5	15.00
> 256	17.00
Indiana Packers Corporation (2015)	



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weight and carcass weight, total amount, and average sort loss per pig were estimated for each marketing time and the entire barn. The sorting accuracy was determined by comparing percentage of pigs sold correctly for each marketing, and the entire barn was based on the actual pigs marketed versus those that should have been marketed without error.

Carcass weight and sort loss data were obtained from three large wean-finish barns. Using modeling procedures, statistics associated with the accuracy of sorting were estimated. Three marketing error rates for BWEE were evaluated for each of the three wean-to-finish barns. The actual error rates are for live pigs marketed. The estimated group is live pigs marketed assuming no sorting error. Randomly marketed pigs are those expected when pigs are randomly sorted for marketing.

Results

The averages and standard deviations for body and carcass weight for each marketing cut is presented in Table 2. The simulated pigs required approximately 163, 175 and 187 d to achieve average target market body weights of 243, 265 and 287 lbs.

The averages and standard deviations for body and carcass weight for each marketing cut (MCUT) at each level of BWEE and PNVE are shown in Tables 3 and 4, respectively. The overall average carcass weight with no sorting errors

Table 3. Averages and standard deviations (SD) of marketed body weight with different magnitude of body weight estimation errors (BWEE) and percent pigs not visually evaluated (PNVE) for each marketing cut (MCUT) and overall.

BWEE, %	PNVE, %							
	0		8		16		24	
First MCUT	Average	SD	Average	SD	Average	SD	Average	SD
0	296.1	14.1	295.4	14.4	294.6	14.6	293.8	14.8
4	294.5	15.8	293.8	16.0	293.0	16.1	292.3	16.2
6	292.8	17.3	132.53	17.4	291.4	17.5	290.7	17.6
8	290.9	18.7	292.2	18.8	289.6	18.9	288.9	19.0
Second MCUT								
0	288.5	6.0	289.9	10.7	291.1	13.5	291.6	15.1
4	288.2	10.5	289.6	13.4	290.7	15.4	291.2	16.5
6	287.8	13.7	289.6	13.4	290.2	17.3	290.7	18.2
8	287.3	16.4	288.5	18.0	289.6	19.2	290.0	19.9
Third MCUT								
0	276.6	20.0	277.7	21.1	279.2	22.6	280.4	23.8
4	277.7	21.4	278.8	22.4	280.1	23.7	281.3	24.9
6	278.9	22.8	279.9	23.7	281.2	24.8	282.3	25.8
8	280.3	24.4	281.2	25.0	282.5	26.0	283.5	26.9
Overall								
0	287.1	13.4	287.7	15.4	288.3	16.9	288.6	17.9
4	286.8	15.9	287.4	17.2	287.9	18.4	288.3	19.2
6	286.5	17.9	287.1	19.0	287.6	19.9	287.9	20.6
8	286.2	19.8	286.7	20.6	287.2	21.4	287.5	21.9

BWEE: 0, 4, 6 and 8% is the standard deviation of the error as a percent of the actual body weight. PNVE: percent of pigs that are not seen or not considered. MCUT is the marketing cut, first, second or third with marketing cuts of 25, 25 and the remaining 50 % of the pigs in the barn, respectively.

Table 2. Ages to achieve specific target weights and average body weights (BW) and carcass weights (CW) at specific ages.

BW (lb.)	Average Age (d)	Standard Deviation
243	162.8	14.9
265	174.7	17.4
287	187.4	20.4
Average BW		
Age (d)	(lb.)	SD
169	259.7	28.7
179	278.4	30.6
193	303.3	33.5
Average CW		
Age (d)	(lb.)	SD
169	187.4	21.1
179	201.1	22.7
193	219.1	24.7

was 207.3 lbs., slightly less than the midpoint of the processor's acceptable carcass weight range (208.2 lbs.). This marketing strategy essentially targets the middle of the pork processors acceptable carcass weight range and minimizes sort loss. Increased BWEE decreased the average body and carcass weights of the first MCUT, had smaller impacts on the second MCUT, and increased the average body and carcass weights for the third MCUT. The PNVE errors decreased the body and carcass weight averages of the first MCUT, and increased the average body and carcass weights of pigs marketed the second and third MCUTs.

Overall, with no errors, the standard deviations for body and carcass weight are much smaller for the second MCUT than the first and the third MCUTs. Pigs sold the second MCUT without error should be the most uniform groups of pigs marketed.

The impact of BWEE and PNVE to increase the standard deviations for body and carcass weight differed for each MCUT. For the first MCUT, the percentage PNVE had little impact on the standard deviations for body and carcass weight. For the first MCUT, as the BWEE increased, the standard deviations for body and carcass weight both increased. For both second and third MCUT, simulated BWEE and PNVE intervals had similar magnitude of impacts to increase the standard deviations for body and carcass weight.

Overall, the standard deviations for body and carcass weight for the second MCUT are much more sensitive in absolute, and especially proportional, change to BWEE and PNVE than the first and third MCUTs.

Table 4. Averages and standard deviations of marketed carcass weight with different magnitude of body weight estimation errors (BWEE) and percentage of pigs not visually evaluated (PNVE) for each marketing cut (MCUT) and overall

BWEE	PNVE							
	0		8		16		24	
First MCUT	Average	SD	Average	SD	Average	SD	Average	SD
0	213.9	11.1	213.4	11.3	212.8	11.5	212.2	11.6
4	212.7	12.3	212.2	12.4	211.6	12.4	211.1	12.5
6	211.5	13.3	211.0	13.4	210.5	13.4	210.0	13.5
8	210.1	14.3	209.7	14.3	209.7	14.3	208.7	14.4
Second MCUT								
0	208.3	5.9	209.3	8.8	210.2	10.7	210.6	11.8
4	208.1	8.7	209.1	10.6	209.9	11.9	210.3	12.7
6	207.9	10.8	208.8	12.2	209.6	13.2	209.9	13.9
8	207.4	12.6	208.4	13.7	209.1	14.6	209.5	15.1
Third MCUT								
0	209.7	15.1	200.5	15.9	201.6	16.9	202.5	17.7
4	200.5	16.1	201.3	16.7	202.3	17.7	203.1	18.5
6	201.4	17.1	202.1	17.7	203.1	18.5	203.9	19.2
8	202.4	18.2	203.0	18.6	203.9	19.3	204.7	20.0
Overall								
0	207.3	10.7	207.7	12.0	208.2	13.0	208.4	13.7
4	207.1	12.3	207.5	13.2	207.9	14.0	208.2	14.6
6	206.9	13.7	207.3	14.4	207.7	15.1	207.9	15.5
8	206.7	15.0	207.0	15.6	207.4	16.1	207.6	16.5

BWEE: 0, 4, 6 and 8% is the standard deviation of the error as a percent of body weight. PNVE: percent of pigs that are not seen or not considered. MCUT is the marketing cut, first, second, or third. The marketing cuts include 25, 25 and the remaining 50 % of the pigs in the barn.

Standard deviations for the second MCUT increased from 5.9 lbs. with no error to 15.1 lbs. with 8% BWEE and 24% PNVE. For the second MCUT, the second 25% of the pigs marketed should be the most uniform in terms of carcass weight. However, with greater levels of BWEE and PNVE, the standard deviations for carcass weight for the second MCUT approached those of the first MCUT.

Averages for the percentage of pigs marketed correctly for each MCUT are shown in Table 5. As the BWEE or PNVE increased, the percentage of pigs sold correctly decreased. Percentages of pigs sold correctly for the second MCUT were more greatly affected by BWEE and PNVE than the first and third MCUTs. This is likely caused by the fact that the pigs that should have been sold for both the first and third MCUTs were sold incorrectly at the second MCUT. The percentage of pigs sold correctly for the third MCUT is the least sensitive to the level of BWEE and PNVE.

The averages and standard deviations for carcass weight for every MCUT for each barn are presented in Table 6. Overall, the pigs were heaviest from Barn B, with an average carcass weight of 222.4 lbs.; intermediate for Barn A, with an average carcass weight of 211.0 lbs.; and lightest for Barn C, with an average carcass

weight of 201.1 lbs. The optimal carcass weight range for the pork processor was 181 to 235.5 lbs., with a midpoint of 208.2 lbs.

The average carcass weights for each barn are shown in Table 7. The estimated body and carcass weights are those expected if pigs were sorted for marketing without error. For example, pigs with the heaviest carcass weights in the barn were correctly identified and marketed each marketing cut. The actual averages and standard deviations are those for the pigs actually marketed. The random averages are those expected if pigs were randomly marketed each day of marketing.

The actual average of the first MCUT is decreased when some of the heaviest pigs are not marketed and lighter pigs are marketed in their place. The actual carcass weight averages for the first MCUT are 6 to 9 lbs. less than estimated average carcass weight, and 12.1 to 14.6 lbs. greater than random CW averages.

Table 5. The accuracy of pig sorting (% of pigs marketed correctly) with different magnitude of body weight estimation errors (BWEE) and percent PNVE pigs (PNVE) for each marketing cut (MCUT) and overall

BWEE	PNVE			
	0	8	16	24
First MCUT				
0	100	91.2	83.89	76.08
4	84.95	79.50	74.09	69.89
6	78.34	73.42	68.57	64.94
8	72.73	68.10	63.72	60.45
Second MCUT				
0	100	84.79	72.81	63.59
4	67.08	62.73	58.07	54.23
6	54.73	51.91	48.63	46.14
8	46.86	44.85	42.32	40.68
Third MCUT				
0	100	95.12	91.01	88.41
4	85.95	84.15	82.26	80.64
6	80.03	78.74	77.44	76.28
8	75.33	74.39	73.42	72.54
Overall				
0	100	91.70	84.67	79.12
4	80.98	77.63	74.17	71.35
6	73.28	70.70	68.02	65.91
8	67.56	65.43	63.22	61.55

BWEE: 0, 4, 6 and 8% is the standard deviation of the error as a percent of the actual. PNVE: percent of pigs that are not visually evaluated. Marketing cuts for MCUT 1, 2, and 3 were 25, 25 and the remaining 50 % of the pigs in the barn, respectively.

Table 6. Number of pigs, average and standard deviation for carcass weight of each barn.

Carcass weight, lbs.	BARN A			BARN B			BARN C		
	N	Average	SD	N	Average	SD	N	Average	SD
First MCUT	1386	207.6	14.7	1368	213.4	15.3	1017	194.3	14.2
Second MCUT	1344	213.7	14.5	1158	227.7	19.7	1356	201.0	13.3
Third MCUT	1190	211.8	20.3	1305	227.5	19.8	1384	205.9	18.4
Overall	3920	211.0	16.7	3831	222.5	19.5	3757	201.0	16.2

The average ages for each marketing cut (MCUT) are 174.0, 185.5 and 199.7 d for Barn A; 168.5, 182.8, and 193.3 d for Barn B, and 171.5, 182.5, and 199.0 d for Barn C.

The actual average carcass weights of the second MCUT were within 0.37 to 1.76 lb. of the averages estimated without error. The standard deviations of the actual carcass weights for the second MCUT were from three to almost five times greater than those estimated if pigs were sold without error.

The actual average carcass weights for the third MCUT were 6.2 to 9.1 lbs. greater than that estimated if pigs were sold without error. The increased carcass weight of the pigs actually marketed was due to heavier, faster growing pigs not correctly marketed the first two MCUTs and remaining to be sold in the third MCUT. The proportion of pigs sold correctly each MCUT are shown in Table 8. The percentages of pigs sold correctly were greatest for the third MCUT and least for the second MCUT.

The sort loss estimated without marketing error, actual sort loss, and sort loss

Table 7. Averages and standard deviations for estimated carcass weight (CW) for each marketing cut (MCUT) and overall for each barn when sorting error is removed.

BARN A						
CW (lb.)	Estimated		Actual		Random	
	First MCUT	214.1	8.8	207.7	14.7	193.5
Second MCUT	212.0	4.2	213.7	14.5	213.1	21.1
Third MCUT	205.1	13.3	211.8	20.3	232.0	23.2
Overall	210.6	10.1	211.0	16.7	211.9	26.4
BARN B						
First MCUT	222.1	9.3	213.5	15.3	201.4	18.8
Second MCUT	226.0	3.4	227.7	19.7	226.8	21.5
Third MCUT	218.4	13.2	227.5	19.8	243.2	23.5
Overall	222.0	10.1	222.5	19.5	223.3	27.7
BARN C						
First MCUT	200.9	9.0	194.3	14.2	179.7	17.7
Second MCUT	201.3	4.0	201.0	13.3	199.3	19.7
Third MCUT	199.7	12.9	205.9	18.4	220.6	20.7
Overall	200.6	9.5	201.0	16.2	201.8	25.4

The average ages for each marketing cut (MCUT) are 174.0, 185.5 and 199.7 d for Barn A; 168.5, 182.8, and 193.3 d for Barn B, and 171.5, 182.5, and 199.0 d for Barn C.

estimated with random marketing are shown in Table 9. Without error, a few pigs are sold too heavy the first MCUT and a few pigs are sold too light the third MCUT. Without error, there is no sort loss estimated for the pigs in the second MCUT. The increased sort loss of the actual data versus estimated for the second MCUT is primarily due to heavy pigs that should have been sold in the first MCUT that were actually marketed in the second MCUT with substantial sort loss. The increased third MCUT sort loss is primarily due to heavy pigs not being sold the first and second MCUT and therefore sold with heavy sort loss in the third MCUT.

The actual sort loss per pig was 1.21, 5.74 and 0.56 dollars per pig greater than that estimated without marketing error for Barn A, B, and C. Although the three barns had similar sorting accuracy, the difference between the actual and estimated sort loss of Barn B was much greater than for the other two barns. The sort loss of the heavier pigs of Barn B is more sensitive to decreased sorting accuracy. This is because with greater average carcass weights, a greater percentage of pigs not sold on the correct MCUT in Barn B were marketed on a subsequent MCUT with substantial sort loss. The sort loss of the barn with the overall lightest pigs, Barn C, is least sensitive to the accuracy of sorting. With a lower mean body and carcass weight, pigs not correctly marketed for Barn C have a lower probability to have sort loss when marketed a subsequent marketing cut.

Table 8. Percentage pigs sold correctly for each marketing cut (MCUT) and overall for each barn.

	BARN A	BARN B	BARN C
First MCUT	65.3	59.1	58.5
Second MCUT	46.1	35.0	47.1
Third MCUT	67.2	63.4	67.5
Overall	59.3	53.3	57.7

Discussion

Sort loss information currently provided to pork producers — number of pigs with sort loss, sort loss per pig with sort loss, sort loss per pig in the barn, and total sort loss for the barn — do not reflect the accuracy with which pigs are sorted for market. Statistics that are better indicators of the accuracy of sorting pigs for market identified via simulation include: (1) the percentage of pigs sold correctly, especially for the second MCUT, (2) the magnitude of the errors for pigs sold incorrectly, (3) the distribution of the sorting errors for the first 2 MCUTs, and (4) the standard deviations for carcass weight for pigs of the second MCUT. The percentage of pigs sold correctly and the standard deviations in carcass weight of pigs sold the second MCUT of a three-day marketing strategy are sensitive to level of sorting accuracy. These four statistics could be estimated from currently available individual pig carcass weight data and marketing dates from pork processors.

The value of primal and subprimal cuts are based on specific weight classes. Variation in carcass weight is the major source of variation for the weights of primal and subprimal cuts. By impacting the distribution of carcass weights, the sorting errors can impact the value of the carcasses by affecting the distribution of primal and subprimal cut weights. The accuracy of sorting pigs for marketing must be taken into account in any analyses of the pork production/pork processing systems.

Table 9. Average and Sum of sort loss of each marketing cut (MCUT) and overall for each barn

BARN A						
Sort Loss (\$)	Estimated		Actual		Random	
	Average	Sum	Average	Sum	Average	Sum
MCUT						
First	0.61	845	0.76	1057	2.21	3062
Second	0.00	0.00	1.30	1742	3.57	4803
Third	0.47	554	2.85	3393	14.08	16754
Overall	0.36	1399	1.58	6192	6.28	24619

BARN B						
Sort Loss (\$)	Estimated		Actual		Random	
	Average	Sum	Average	Sum	Average	Sum
MCUT						
First	2.02	2766	1.62	2214	1.50	2058
Second	0.00	0.00	9.54	11051	10.10	11698
Third	0.09	114	8.87	11579	22.17	28926
Overall	0.75	2880	6.49	24845	11.14	42682

BARN C						
Sort Loss (\$)	Estimated		Actual		Random	
	Average	Sum	Average	Sum	Average	Sum
MCUT						
First	0.17	168	0.76	769	4.56	4635
Second	0.00	0.00	0.42	564	1.90	2572
Third	0.64	892	1.32	1828	5.83	8069
Overall	0.28	1060	0.84	3160	4.07	15276

The average ages for each marketing cut (MCUT) are 174.0, 185.5 and 199.7 d for Barn A; 168.5, 182.8, and 193.3 d for Barn B, and 171.5, 182.5, and 199.0 d for Barn C. Sum is the total sort loss for the MCUT or the overall barn. Estimated if pigs were sold with no error, the actual data and if pigs were marketed at random.

Summary

Variables that indicate the magnitude and type of sorting errors that have been identified could be calculated from information currently provided by pork processors. These new statistics could be used to evaluate the accuracy of sorting-marketing crews. In-depth stochastic modeling of pork production systems, including pork processing, should consider the impact of sorting errors on the variation in carcass weight and subsequent variation in primal and subprimal cut weights.

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