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Hog Price and Volume Comparisons across Alternative Sale Types, Emphasis on COVID-19 Disruptions

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Executive Summary

In 2020, due to COVID-19, swine and pork markets in the United States experienced the worst disruption since 1998. We seek to inform discussions about marketing outcomes and possible structural changes by establishing performance baselines and providing definitions and descriptions for transactions between producers and packers. From 2010–2020, prices were highest in 2014 and lowest in 2020. We estimate simple models to see how changes in pork packing plant capacity utilization impact market hog prices by sale type. Results indicate that negotiated prices are the most sensitive to increases in utilization, decreasing 2.34% for every 1% increase in utilization. Negotiated sales volume has become incredibly thin, comprising only 1.52% of all hogs reported in 2020, compared with 14.65% back in 2002. There is a need, on occasion, to modify how data is published which directly contributes to the effectiveness of Livestock Mandatory Reporting (LMR). For example, other purchase arrangement sales increased in volume in 2016 as hogs raised without ractopamine or antibiotics were reclassified from swine or pork market formula sales. Sales based on the CME Lean Hog Index or Pork Cutout Index have been reclassified as swine or pork market formula sales. The correlation of pork carcass cutout values and negotiated hog prices has deteriorated from 0.919 in 2013 to 0.255 in 2020. Separating swine or pork market formula sales into swine formula sales and pork formula sales could improve price correlations. Summaries of price distributions provide a snapshot of marketing outcomes and aid in bringing further transparency to the marketplace.

The outbreak of the novel coronavirus (COVID-19) disrupted hog and pork markets in the United States to an extent not seen since 1998 when an oversupply of hogs, relative to available packing capacity, drove negotiated hog prices down to the lowest levels in decades. Hog sales based on formula contracts did not decline to a similar extent. This scenario, along with the ongoing concerns over packer concentration, prompted Congress to pass the Livestock Mandatory Reporting (LMR) Act of 1999. The intent of the Act was to increase price transparency in the livestock industry.¹ The LMR program encourages competition in the marketplace by bringing transparency, breadth, and depth to market reporting. The U.S. Department of Agriculture (USDA) Agricultural Marketing Service (AMS) is responsible for implementing LMR and for publishing information in ways that producers can readily understand and use.

In the decades since, stakeholders have greatly benefitted from access to these reports through enhanced decision making and market efficiency. Multiple shocks have occurred since 1998, most notably porcine epidemic diarrhea virus (PEDV) in 2014 and COVID-19 in 2020. These shocks have reinforced the importance of LMR to the livestock industry, commerce, and consumers. The availability of this information allows market participants to better understand disruptions and anticipate impacts. Looking back at the data provides a way to document and corroborate impacts.

This paper clarifies definitions used in swine marketing and examines market activity from 2010 through 2020. In particular, we focus on prices and volumes with an emphasis on their distributions and seasonal components. From this, we identify particular trends, nuances, and suggest changes to the way certain sales could be reported. The intended impact of our analysis is to create a common understanding among stakeholders of changes in the swine market so that future discussions about price discovery and price reporting can be more informed.

Definitions

Swine sales are categorized into six broad types for reporting purposes. A seventh category, packer owned, also exists and is important for understanding slaughter volumes. Definitions include:²

1. Negotiated: A cash or spot market purchase by a packer of swine from a producer under which the base price for the swine is determined or known (hard priced) by seller-buyer interaction and agreement regardless of the method of price discovery used on a delivery day.

¹ Additional background on the LMR Act can be found at <https://www.ams.usda.gov/sites/default/files/media/LivestockMandatoryReportingBackground.pdf>.

² The Electric Code of Federal Regulations, Title 7: Agriculture, Part 59-Livestock Mandatory Price Reporting (<https://ecfr.federalregister.gov/current/title-7/subtitle-B/chapter-I/subchapter-C/part-59>) provides the official definitions of these sales types, with USDA-AMS providing definitions with further detail, including examples, in presentations at stakeholder meetings (<https://www.ams.usda.gov/sites/default/files/media/LPSNationalPorkBoardPresentation20170907.pdf>).

2. Negotiated Formula: A purchase of swine by a packer which is similar to a negotiated purchase where there is interaction between a buyer and a seller to settle on a price (unknown at the time to contract is signed) where a formula is used as the base.
3. Other Market Formula (OMF): A purchase of swine by a packer in which the pricing mechanism is a formula price based on one or more futures or option contracts.
4. Swine or Pork Market Formula (SPMF): Purchase of swine by a packer in which the pricing mechanism is a formula price based on a market for swine, the CME Lean Hog Index or Pork Cutout Index, pork, or a pork product, other than any formula purchase with a floor, window, or ceiling price, or a futures or options contract for swine, pork or pork product.
5. Other Purchase Arrangement (OPA): A purchase of swine by a packer which is not a negotiated purchase, swine or pork market formula purchase, or other market formula purchase. If it does not fit the other categories it goes here. A typical example would be a cost of production contract.
6. Packer Sold: Swine that a packer, including a subsidiary or affiliate of a packer, owns for more than 14 days immediately before sale or slaughter; and sold for slaughter to another packer. As a point of clarification, packer sold hogs are priced using types 1–5 but not included in those sale types because they are owned by a packer and then sold to another packer.
7. Packer Owned: Swine that a packer, including a subsidiary or affiliate of the packer, owns for at least 14 days immediately before slaughter. Price data are not reported for packer-owned, because those hogs are transferred internally from one business area of the company (hog feeding) to another (slaughter-processing).

For each producer-sold sale type and the packer-sold listing (which includes all sale types), an average base price and net price is published. The base price is the price paid before the application of any premiums or discounts. The net price differs from the base price due to the myriad of carcass quality differences and non-carcass merit attributes present, and paid for, in the pork industry. For this paper we focus on net prices. Much attention is given to reported prices within LMR, but LMR also mandates reporting of head counts, which are also discussed in this paper.

The Swine Contract Library (SCL) contains a listing of SPMF and OPA contracts offered by packers to swine producers for the purchase of swine.³ The SCL was implemented and is maintained by the Packers and Stockyards Division of USDA-AMS and is intended to aid in the price discovery process and provide equal access to market information for all market participants. Formula contract details include the USDA-AMS report numbers (names) referenced in establishing base prices and contract terms for calculating prices. The SCL does not provide any indication on the quantity of hogs purchased under each specific formula.

³ More information and summary reports are available at <https://www.ams.usda.gov/rules-regulations/packers-and-stockyards-act/regulated-entities/swine-contract-library>.

Data

The LMR Act of 1999 requires federally inspected (FI) swine processing plants that slaughter an average of more than 100,000 head of barrows and gilts (or a company, termed “person” in the regulations, that slaughters more than 200,000 head of sows and/or boars) annually to report prices and other characteristics (including head counts) of their transactions. In 2020, packing plants that slaughtered 100,000 head or more annually accounted for 98.6% of the FI hog slaughter.⁴ USDA-AMS uses what is referred to as the 3/70/20 guideline to ensure confidentiality of reported market information under LMR.⁵ Confidentiality guidelines can preclude publishing some market information.

We collect data from the *National Daily Direct Hog Prior Day Report - Average Net Price Distribution* (commonly referred to as the LM_HG215 report). This report is derived from the *National Daily Direct Hog Prior Day Report - Slaughtered Swine* (LM_HG201).⁶ The data in LM_HG215 report represent the distribution of average net prices in increments of \$2/cwt from the weighted average net price of each purchase type. Purchase types include negotiated, OMF, SPMF, OPA, negotiated formula, combined (negotiated and negotiated formula), and packer sold (all purchase types). Negotiated formula purchases and the combined category are excluded from this analysis because data was not available prior to 2016 and since then has only been intermittently published due confidentiality.

Table 1 shows 2020 head counts by sale type as a percentage of different groupings of total head. These data are derived from the LM_HG201 report. Packer owned hogs accounted for 36.76% of total barrow and gilt volume, while negotiated and negotiated formula accounted for 1.52% and 0.15%, respectively. Looking only at producer sold hogs, negotiated sales were 2.62%, and SPMF sales were 49.12%, surpassing the next closest type, OPA, which were 32.92% of the volume in 2020.

⁴ Federally inspected slaughter accounts for the majority of pork production. Total commercial U.S. hog slaughter in 2020 was 131.563 million head, of which 130.782 million head, or 99.4%, was FI with non-federally inspected, state-inspected, or custom-exempt slaughter accounting for 780,800 head or 0.6%. Barrow and gilt slaughter is the vast majority of FI hog slaughter (97.2% in 2020), with the remaining comprised of sow and boar slaughter. More information about different types of slaughter, classes of hogs and FI plants and head slaughtered by size group is available in the USDA National Agricultural Statistics *Livestock Slaughter Annual Summary* reports (<https://usda.library.cornell.edu/concern/publications/r207tp32d>).

⁵ More information about this guideline is available at <https://www.ams.usda.gov/sites/default/files/LMRConfidentialityGuidelinePresentation.pdf>.

⁶ Head counts in the LM_HG215 report are lower than in LM_HG201 report which also include hogs sold on a live weight basis and hog sales where no price is reported. Packer-owned hogs are not included in the LM_HG215 report because price data are not reported.

Table 1. National Barrow and Gilt Head Counts as a Percentage of Total Head Count Groupings, 2020

Sale Type	Negotiated	Negotiated Formula	Other Market Formula	Swine or Pork Market Formula	Other Purchase Arrangement	Packer Sold	Packer Owned
All Hogs	1.52%	0.15%	8.72%	28.40%	19.04%	5.41%	36.76%
Producer Sold + Packer Sold Hogs	2.40%	0.24%	13.79%	44.92%	30.10%	8.56%	
Producer Sold Hogs	2.62%	0.26%	15.08%	49.12%	32.92%		

Data Source: USDA-AMS National Daily Direct Hog Prior Day Report - Slaughtered Swine (LM_HG201).

Summary Statistics

Tables 2 and 3 summarize daily weighted average prices and daily head counts, respectively. As shown in table 2, negotiated sales clearly have the highest day-to-day variability in prices, as measured by the coefficient of variation.⁷ Furthermore, negotiated prices have been the lowest, on average, for a given year since 2015. The year 2014 saw the highest prices overall and 2020 the lowest, corresponding to the PEDV and COVID-19 outbreaks. For all sale types, prices were higher in 2010–2014 than in 2015–2020. We can explore these periods further by looking at the dispersion of prices. For each year from 2010–2013, price variability stayed below 11% for all sale types. In 2014, this jumped at least 5% for all but OMF sales. This higher level of variability did not subside from 2015–2020. Coefficients of variation for all sale types in this period stayed above the pre-2014 level. This is important because day-to-day price variability from 2015–2020 was higher than the historical level, leading to increased price risk.

Two key points to focus on in table 3, which shows annual volume metrics, are the steady decline of negotiated sales and the growth of OPA sales, which have grown considerably in volume. In 2020, compared to 2019, packer sold volume increased by 40%. Labor shortages induced by COVID-19 outbreaks would often cripple a packing plant’s operating capacity, forcing packers to scramble to get hogs processed, including by selling them to other packers. The only other sale type that also grew in 2020 was SPMF, which showed a modest 7% increase in volume over 2019. In 2014, compared to 2013, OMF sales saw a 47% increase in volume while other sale types stayed roughly within 10% of the prior year’s volume.

⁷ Coefficient of variation (CV) is a measure of the relative risk, expressed as a percentage of the mean. In the case of prices, as in Table 2, it captures how far prices are expected to deviate from the mean for a given year and sale type. For example, in 2010, negotiated sales had a mean of \$75.04/cwt and a CV of 10.59%. So, for any given day in 2010, negotiated prices would be expected to be between \$67.45 and \$83.35. Coefficient of variation is particularly useful because it allows for comparisons of relative risk across both years and sale types because it is a percentage and not an absolute number. A smaller CV means less risk.

Table 2. Summary Statistics of National Barrow and Gilt Carcass Net Prices

Sale Type	Year	Mean	Median	Min	Max	Coeff of Var
Negotiated	2010	75.04	76.14	59.72	89.67	10.59%
	2011	90.39	91.24	71.63	108.19	9.31%
	2012	85.07	84.57	65.98	104.53	8.40%
	2013	89.15	88.97	72.81	104.39	9.73%
	2014	104.19	107.01	75.58	134.07	16.26%
	2015	68.42	70.25	48.15	83.36	14.01%
	2016	61.99	63.58	41.71	83.95	18.19%
	2017	67.85	65.82	49.05	89.75	15.53%
	2018	61.32	61.47	37.92	85.38	18.21%
	2019	61.68	56.16	42.17	83.45	22.49%
2020	47.80	50.34	27.33	66.79	23.71%	
Other Market Formula	2010	70.53	70.96	57.98	78.63	8.05%
	2011	84.41	85.67	70.06	95.34	8.07%
	2012	87.58	88.07	78.07	99.12	6.84%
	2013	87.84	86.02	80.49	98.07	6.20%
	2014	96.94	98.22	81.55	114.04	9.15%
	2015	75.59	79.04	58.77	87.01	11.47%
	2016	68.22	68.25	51.35	82.14	12.92%
	2017	69.42	67.07	61.01	85.23	9.37%
	2018	67.70	68.78	55.22	81.87	11.22%
	2019	72.53	71.60	56.79	87.56	12.03%
2020	65.76	65.46	51.73	77.63	7.69%	
Swine or Pork Market Formula	2010	75.36	76.23	61.77	88.74	9.95%
	2011	90.12	90.80	72.29	107.88	8.54%
	2012	85.48	84.50	67.56	103.25	8.28%
	2013	89.48	88.59	74.05	104.32	9.74%
	2014	105.18	108.29	78.13	134.20	15.78%
	2015	70.41	72.47	53.07	83.27	12.63%
	2016	65.38	66.17	47.60	85.21	15.59%
	2017	71.74	69.39	54.58	93.08	14.23%
	2018	65.40	65.43	45.74	86.29	14.65%
	2019	67.80	64.00	51.99	84.93	15.83%
2020	60.95	60.50	45.08	79.24	15.06%	
Other Purchase Arrangement	2010	74.80	74.64	66.88	83.19	6.64%
	2011	88.75	89.18	74.03	101.46	6.88%
	2012	87.57	86.82	79.28	100.82	5.13%
	2013	90.63	89.19	80.73	102.21	7.12%
	2014	100.22	102.55	78.68	122.85	12.88%
	2015	73.72	74.80	61.48	81.62	7.31%
	2016	69.26	69.04	57.43	84.50	10.22%
	2017	73.94	71.40	61.66	92.85	11.24%
	2018	69.13	68.90	55.94	84.47	9.37%
	2019	71.37	69.07	58.76	84.20	9.75%
2020	67.78	66.82	56.65	81.06	8.10%	
Packer Sold	2010	76.95	76.87	65.20	88.21	9.06%
	2011	90.62	90.79	74.26	108.85	7.38%
	2012	85.99	85.18	71.03	102.41	7.52%
	2013	90.79	89.46	76.17	105.25	9.04%
	2014	106.98	110.39	79.89	134.75	15.13%
	2015	71.53	73.05	53.85	84.77	12.35%
	2016	66.26	67.41	46.66	86.73	16.18%
	2017	70.95	68.68	52.09	93.18	14.96%
	2018	64.35	64.53	41.81	86.58	16.22%
	2019	65.41	60.51	47.55	86.72	20.31%
2020	58.75	57.79	39.90	77.23	15.71%	

Data Source: USDA-AMS National Daily Direct Hog Prior Day Report - Average Net Price Distribution (LM_HG215).

Table 3. Summary Statistics of National Barrow and Gilt Head Counts

Sale Type	Year	Mean	Median	Min	Max	Sum	Coeff of Var
Negotiated	2010	19,023	18,291	5,946	46,214	4,812,941	32.37%
	2011	15,753	14,221	3,663	35,174	4,001,315	34.04%
	2012	13,615	12,154	6,322	32,913	3,458,111	36.64%
	2013	11,995	11,345	3,344	34,648	2,830,765	35.80%
	2014	9,152	8,680	2,271	20,988	2,333,709	35.00%
	2015	9,142	8,203	2,970	26,336	2,340,283	40.22%
	2016	8,681	7,631	3,791	26,906	2,222,278	43.40%
	2017	9,130	8,018	4,583	29,580	2,319,087	40.98%
	2018	8,212	7,484	3,357	29,872	2,094,100	39.35%
	2019	7,200	6,384	2,059	22,299	1,843,310	44.14%
	2020	6,296	5,598	1,205	23,129	1,605,539	48.27%
Other Market Formula	2010	41,693	41,515	22,250	82,273	10,548,204	22.22%
	2011	38,539	37,130	20,067	76,399	9,789,027	24.88%
	2012	31,149	30,219	13,684	66,057	7,911,905	27.65%
	2013	29,186	27,668	14,339	71,772	6,887,940	30.81%
	2014	39,627	38,785	21,930	61,292	10,104,763	19.39%
	2015	33,277	32,458	17,899	65,697	8,518,815	19.99%
	2016	37,397	36,157	20,899	99,960	9,573,535	25.15%
	2017	43,635	40,941	25,409	89,184	11,083,180	23.23%
	2018	45,159	42,921	28,230	145,234	11,515,453	28.27%
	2019	50,331	47,797	24,581	99,973	12,884,788	24.77%
	2020	38,732	36,947	15,758	87,246	9,876,742	26.14%
Swine or Pork Market Formula	2010	148,245	144,200	91,378	271,676	37,505,954	16.26%
	2011	149,178	145,496	90,023	284,360	37,891,087	17.12%
	2012	162,749	154,785	103,702	322,046	41,338,357	19.54%
	2013	163,315	156,825	66,874	331,143	38,542,373	18.99%
	2014	149,826	149,034	71,378	278,705	38,205,682	15.30%
	2015	171,023	163,296	106,769	319,085	43,781,789	16.54%
	2016	152,168	143,553	88,155	386,748	38,955,106	23.39%
	2017	139,695	131,613	90,043	251,367	35,482,446	18.38%
	2018	128,412	121,325	74,534	454,666	32,744,942	23.91%
	2019	117,524	107,184	55,191	257,358	30,086,260	24.41%
	2020	126,689	122,155	49,289	243,954	32,305,771	27.60%
Other Purchase Arrangement	2010	50,868	47,374	25,012	110,401	12,869,652	24.10%
	2011	59,769	58,001	33,849	111,380	15,181,258	16.79%
	2012	61,575	59,383	38,774	128,816	15,640,044	18.54%
	2013	59,159	57,660	29,409	127,619	13,961,520	19.68%
	2014	49,046	49,229	21,713	91,499	12,506,620	14.73%
	2015	53,182	51,323	31,851	109,393	13,614,560	17.41%
	2016	71,750	70,580	35,326	193,277	18,367,984	26.56%
	2017	81,996	80,139	41,523	148,837	20,826,931	18.66%
	2018	97,192	95,858	49,238	290,006	24,784,044	21.31%
	2019	94,563	90,657	44,883	174,288	24,208,135	18.85%
	2020	84,542	76,657	49,367	180,111	21,558,239	22.39%
Packer Sold	2010	21,513	21,146	13,121	37,411	5,442,735	14.81%
	2011	18,134	17,946	11,376	32,326	4,605,968	16.75%
	2012	17,283	16,551	9,108	36,130	4,389,898	20.97%
	2013	15,827	15,153	10,292	30,729	3,735,160	19.26%
	2014	16,016	16,060	2,030	30,108	4,084,102	19.57%
	2015	16,564	16,652	7,272	36,570	4,240,308	24.25%
	2016	17,687	17,195	10,078	45,317	4,527,855	22.00%
	2017	13,529	12,699	3,948	29,533	3,436,273	24.16%
	2018	9,784	9,413	4,510	33,038	2,494,908	26.92%
	2019	16,145	16,830	801	34,829	4,133,206	33.20%
	2020	22,588	21,736	9,406	46,356	5,760,065	26.71%

Data Source: USDA-AMS National Daily Direct Hog Prior Day Report - Average Net Price Distribution (LM_HG215).

Other market formula sales offer an alternative risk management strategy because they are tied to the futures market. When cash prices are volatile, OMF sales may be preferable because prices can be more stable. In table 2, OMF's coefficient of variation (price variability) is the second lowest, behind only OPA, and was the lowest in both 2014 and 2020. In 2014, futures prices soared in reaction to the spread of PEDV. This incentivized producers to push for OMF contracts. In 2020, however, futures prices fell due to uncertainty around supply disruptions and processing capacity in the midst of COVID-19. Other market formula sales fell by 23% from 2019 to 2020.

Price and Volume Trends

Figure 1 compares daily weighted average carcass net prices for the 2010–2020 period. On an annual basis, prices peaked in 2014 and bottomed out in 2020. Within a particular year, prices are typically weakest in the fourth quarter of the year and strongest during the summer months. The relationship of slaughter hog inventories to packing plant capacity explains, at least in part, these pricing patterns. Also termed packing plant capacity utilization, this measure can account for variation in competition and the leverage position of producers versus packers over time. Figure 2 shows an estimated operational utilization-to-capacity ratio from 2002 through 2019.⁸

Higher prices when utilization is low is consistent with the expectations that packers bid more aggressively to procure hogs to offset fixed operational costs. This was the case in 2014 when a notable rise in death loss due to PEDV health challenges was the primary contributor to a 4.64% decrease in commercial hog slaughter compared to 2013 levels.⁹ With packing plant capacity actually increasing marginally in 2014, utilization levels fell dramatically. This, along with strong domestic and export demand, provided historically strong prices in 2014.

Utilization rebounded at the end of 2014 and returned to a seasonal low in August 2015. It grew throughout 2016, reaching the highest levels since 2007 in the fourth quarter, and remained there through the second quarter of 2017. Utilization above 100%, as measured here, is achievable in the short term (e.g., increased Saturday slaughter) but is generally not sustainable. This led to a capacity constraint in 2016, which reduced hog prices. Added capacity through new plants and additions prevented another such capacity constraint until 2020. For context, U.S. hog slaughter capacity was around 9.5% greater in the spring of 2019 than the fall of 2015, and utilization in the fourth quarter of 2019 exceeded the fourth quarter of 2016 without a similarly uniform drop in hog prices.

⁸ Historical slaughter estimates can be useful as a rough proxy for capacity utilization. We approximate slaughter capacity utilization by taking the current month national FI hog slaughter volume divided by the maximum national FI hog slaughter volume having occurred over the prior three years for the same month. With no estimate of national operational capacity readily available, we implement the maximum volume over the prior three years, by month, as a “presumed” operational capacity. Utilization-to-capacity can exceed 100% when a month's slaughter volume is greater than the maximum slaughter volume experienced for the same month over the prior three years (increasing Saturday slaughter, for example, could result in such a situation). This does not mean the industry exceeds its physical capacity.

⁹ These figures can be found in the USDA National Agricultural Statistics Service's *Livestock Slaughter 2014 Summary*: <https://downloads.usda.library.cornell.edu/usda-esmis/files/r207tp32d/7w62fb830/3n2041706/LiveSlauSu-04-27-2015.pdf>.

With high hog supplies necessitating increased weekend operations and the packing industry already at an elevated utilization-to-capacity level at the start of 2020, COVID-19-related labor shortages amplified the challenge of harvesting market-ready hogs in a timely fashion. While labor shortages have eased some, nationwide operating capacity faces a reduction starting in the third quarter of 2021 as line speeds in plants will be reduced an estimated 2.5%.¹⁰

All prices fell consistently throughout the height of the COVID-19 crisis, with negotiated prices most impacted. The backup of market-ready hogs and associated scarcity of slaughter capacity relative to available supplies kept negotiated prices at low levels. Hogs sold via negotiation represent the marginal or residual supplies in the market and are the first hogs dropped from processing and the last hogs brought back once processing capacity is available. When hogs are plentiful this results in a substantial discount for negotiated hogs relative to other purchase types. Other times it can result in a temporary premium as occurred during the PEDV-driven market of 2014. Since 2015, annual average negotiated prices have remained below all other sale types.

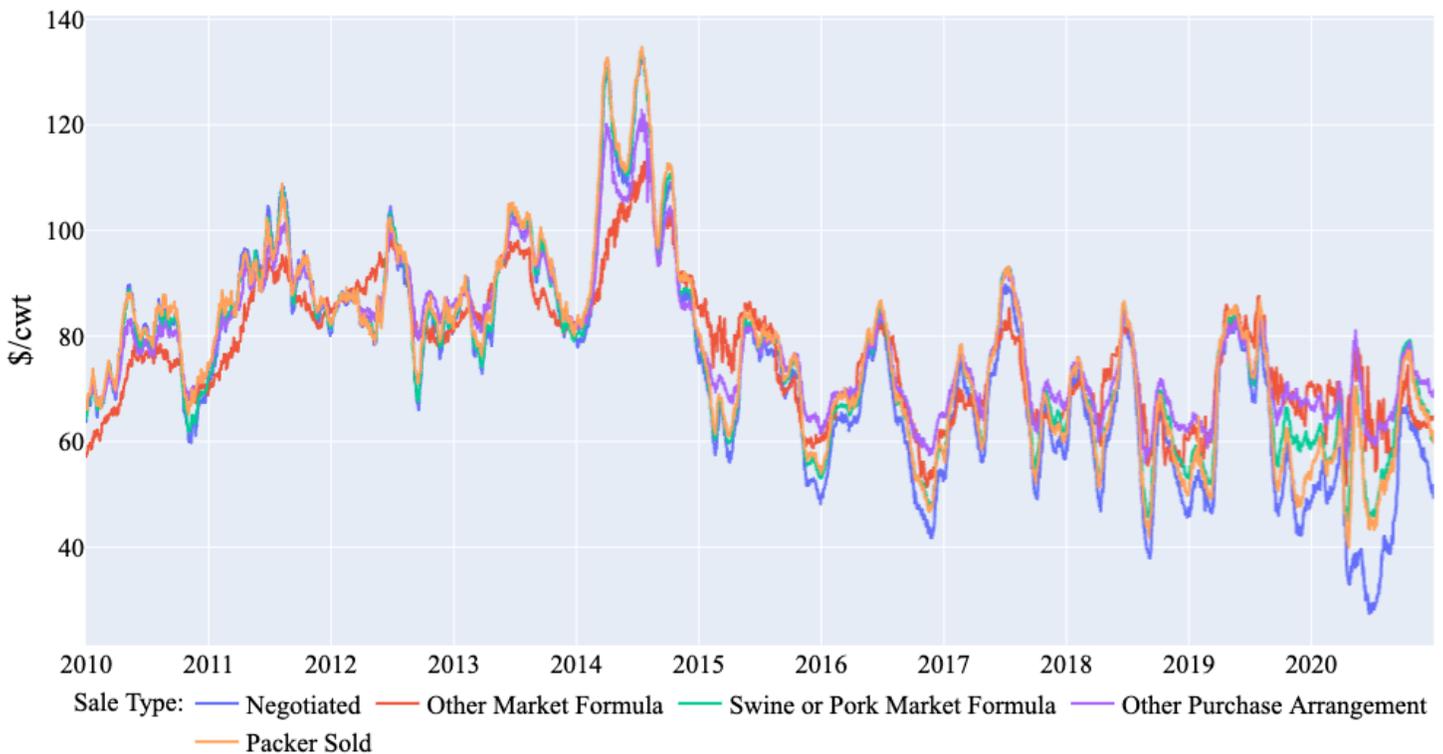


Figure 1. National daily barrow and gilt carcass net prices.

Data Source: USDA-AMS National Daily Direct Hog Prior Day Report - Average Net Price Distribution (LM_HG215).

¹⁰ See *Economic Impact of the Recent District Court Ruling Regarding Line Speeds on the U.S. Pork Industry* for greater detail: <https://nppc.org/wp-content/uploads/2021/05/Impacts-of-NSIS-Decision-on-Pork-Producers-Dr.-Hayes.pdf>.

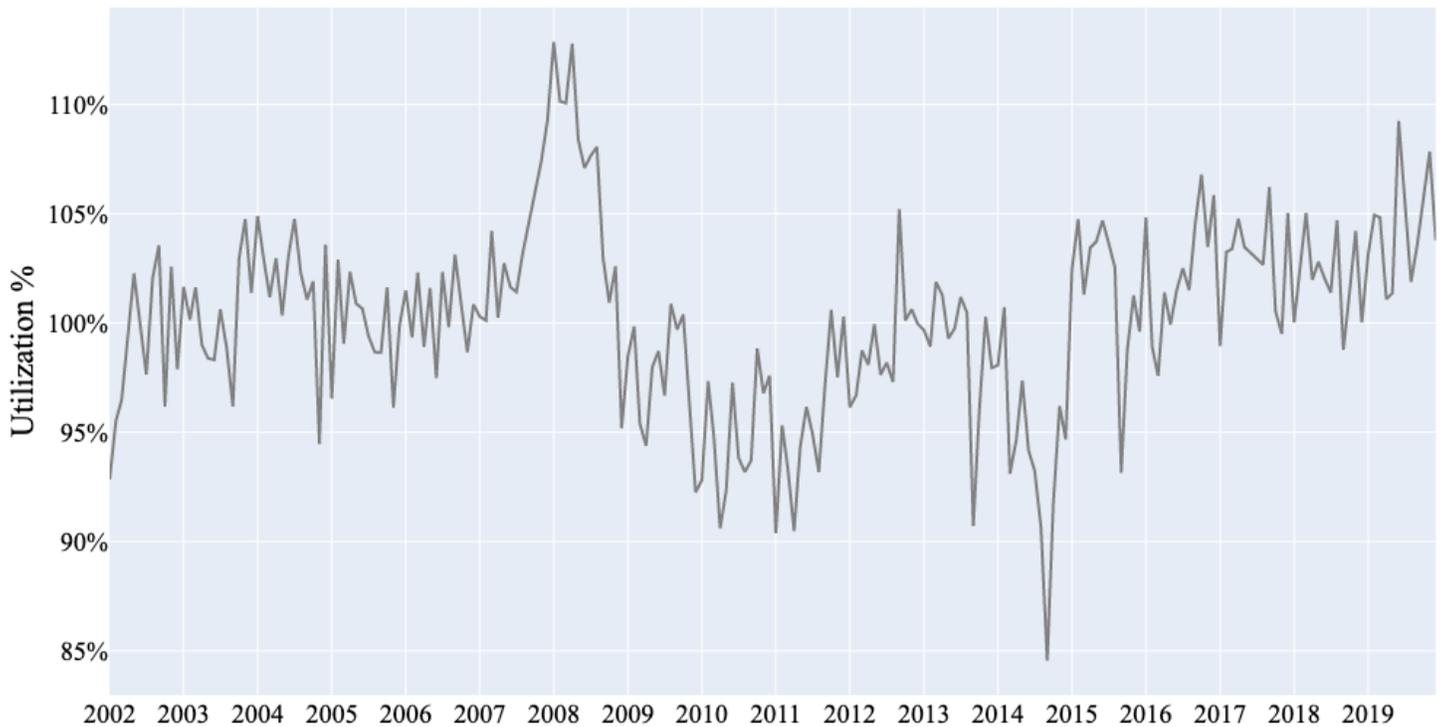


Figure 2. Estimated monthly pork packing plant utilization-to-capacity, 2002–2019.

Data Source: Derived from USDA-NASS *Livestock Slaughter* monthly reports.
Note: Author calculations.

To estimate the effect of packing plant capacity utilization on price, we regressed log prices against log utilization and a trend variable for each sale type. The resulting regression coefficients, listed in table 4, provide simple estimates of the relationship between prices and packing plant capacity utilization. A negative coefficient means that an increase in utilization results in a decrease in price. Negotiated prices are the most sensitive to changes in capacity utilization. We would expect negotiated prices to decrease by 2.34% for every 1% increase in utilization, all else constant. When utilization is high, nearing a capacity constraint, hogs are less valuable to packers. Swine or pork market formula sales are often tied to negotiated prices, so a similar relationship is expected. Other market formula prices, to contrast, would be expected to decrease only 1.27% for a 1% increase in utilization. These prices tend to be more stable and hence can be preferable in periods of uncertainty or shocks.

Table 4. Expected Percentage Change in Price for a One Percentage Change in Utilization, 2002–2019

Negotiated	Other Market Formula	Swine or Pork Market Formula	Other Purchase Arrangement	All Producer Sold	Packer Sold
-2.34%	-1.27%	-2.07%	-1.54%	-1.82%	-2.16%

Data Source: USDA-AMS National Daily Direct Hog Prior Day Report - Slaughtered Swine (LM_HG201) and USDA-NASS *Livestock Slaughter* monthly reports.

Note: Regression coefficients of $\ln(\text{price}) = \ln(\text{utilization}) + \text{trend}$.

Regression estimates best provide information about how small changes—not large changes—in one variable relate to changes in another. To fully characterize the relationship between prices and packing plant capacity utilization, especially for extreme events like in 2020, we can rely on economic intuition.¹¹ Producers sell hogs to packers, and packers process those hogs into pork, which is ultimately purchased by consumers down the retail chain. Our focus here is the market between producers and packers. Packers incur a marginal cost in transforming hogs into pork, measured by the additional cost of buying and processing one more hog, or more generally, the change in total cost divided by the change in quantity. In the case of April and May 2020, packers’ slaughter and processing capacity was fixed, so they could not process additional hogs, and the change in quantity was near zero. Because the denominator of marginal cost (change in quantity) is near zero, the marginal cost ratio is near infinite, and the demand for hogs is near perfectly inelastic once a packer has reached operational capacity. An additional hog is of no value to a packer if they cannot process it. The supply of hogs from producers is near perfectly inelastic in the short term as well; that is, hogs take time to grow and require space that producers need for raising the next batch. This situation leads to an indeterminate price, which could be anything from zero up to what packers decide to pay.

Figure 3 shows total monthly volume (head count) by sale type. An interesting observation here is the relationship between SPMF and OPA. These sale types trended toward each other, with SPMF decreasing in volume and OPA increasing in volume, starting in 2016 and nearly reached an inflection point in 2019. The immediate jump in OPA volume in April 2016 was due to USDA reclassifying hogs raised without ractopamine and/or antibiotics from the SPMF to the OPA category, which is when the number hogs sold with these pricing practices had likely gotten large enough to notice and matter in aggregate to published prices. This is an example of USDA-AMS receiving stakeholder feedback and making enhancements to reports and published data to reflect the dynamics of the industry and the value of market information.

Continued growth in OPA after 2016 is likely two-fold. It is indicative of growing consumer demand for hogs that possess extrinsic attributes. For example, it was not until August 2017 that USDA-AMS began publishing premiums for characteristics related to “animal welfare, antibiotic free, diet/feed, genetics, meat quality, process verified program, sow housing, and weight” in the *National Weekly Direct Swine Non-Carcass Merit Premium* (LM_HG250) report. Also, it is

¹¹ See *National Hog Farmer*, <https://www.nationalhogfarmer.com/marketing/usda-hogs-pigs-very-tough-fall-coming> and <https://www.nationalhogfarmer.com/marketing/even-grim-week-has-flicker-brightness>, for greater detail.

likely that new formula contracts for pricing swine have been introduced over the years that do not necessarily conform to traditional sales categories published by USDA-AMS. The OPA category is a catch-all for methods that do not fit the other three sales categories.

Another notable trend is the steady decline of negotiated sales. Data from the LM_HG201 report shows that negotiated head counts have declined 86.11% from 2002 to 2020, falling from 13,168,274 head in 2002 to 1,828,772 in 2020. Moreover, data from 2002 shows that negotiated sales comprised 14.65% of all hogs reported, compared with 1.52% in 2020.

The decline of negotiated sales is important because these prices are used as a base in many formula contract hog sales. In 2020, 28.40% of hogs sold were priced based upon a SPMF (anecdotal evidence indicates the vast majority of these are a negotiated swine price, not solely pork price formulas). As such, it is critical the negotiated price be representative and reliable as a market price that accurately reflects current supply and demand conditions. If it is not, a large percentage of hogs will be valued off of a base price that may not be a reliable indicator of current market conditions. Also, prices and head counts fluctuate far more than other pricing arrangements, demonstrated by the coefficient of variation in tables 2 and 3. With greater volume and consistency, negotiated sales would be a more reliable base for formula hog sales, but the present market for negotiated hogs is simply too thin to meaningfully indicate market conditions as a whole. This is especially the case during market disruptions.

Price Correlations

Table 5 demonstrates a clear degradation in correlations of the pork cutout value and negotiated and SPMF hog prices. Data for the pork cutout is available starting in 2013 from the *National Daily Pork Report FOB Plant - Negotiated Sales* (LM_PK602). For completeness, the third column shows that the reduction in correlation between negotiated and SPMF has not been nearly as extreme, with 2020 serving as an outlier. In 2014, the tight hog supply strengthened producers' position for negotiated sales, improving the relationship between both negotiated and SPMF sales and wholesale values (pork cutout). The converse to this is in 2019–2020, when capacity constraints weakened negotiated prices and strengthened cutout values, resulting in a weaker relationship. Negotiated sales are the spot market for hogs, but its decline in volume and increased price variability have made it less useful for price discovery and reduced its correlation with wholesale pork values. Negotiated and SPMF sales are used to calculate the CME Lean Hog Index,¹² which is the settlement mechanism for CME Lean Hog Futures, so the degradation of negotiated sales has likely impacted hedging outcomes. Since negotiated prices are not as correlated with other pricing methods, and negotiated volumes are highly variable, the Lean Hog Index may not as accurately reflect market prices. One obvious implication is that basis is less predictable than when negotiated sales were more consistent.

¹² The procedure for calculating the CME Lean Hog Index can be found here: <https://www.cmegroup.com/content/dam/cmegroup/rulebook/CME/II/150/152/152.pdf>.

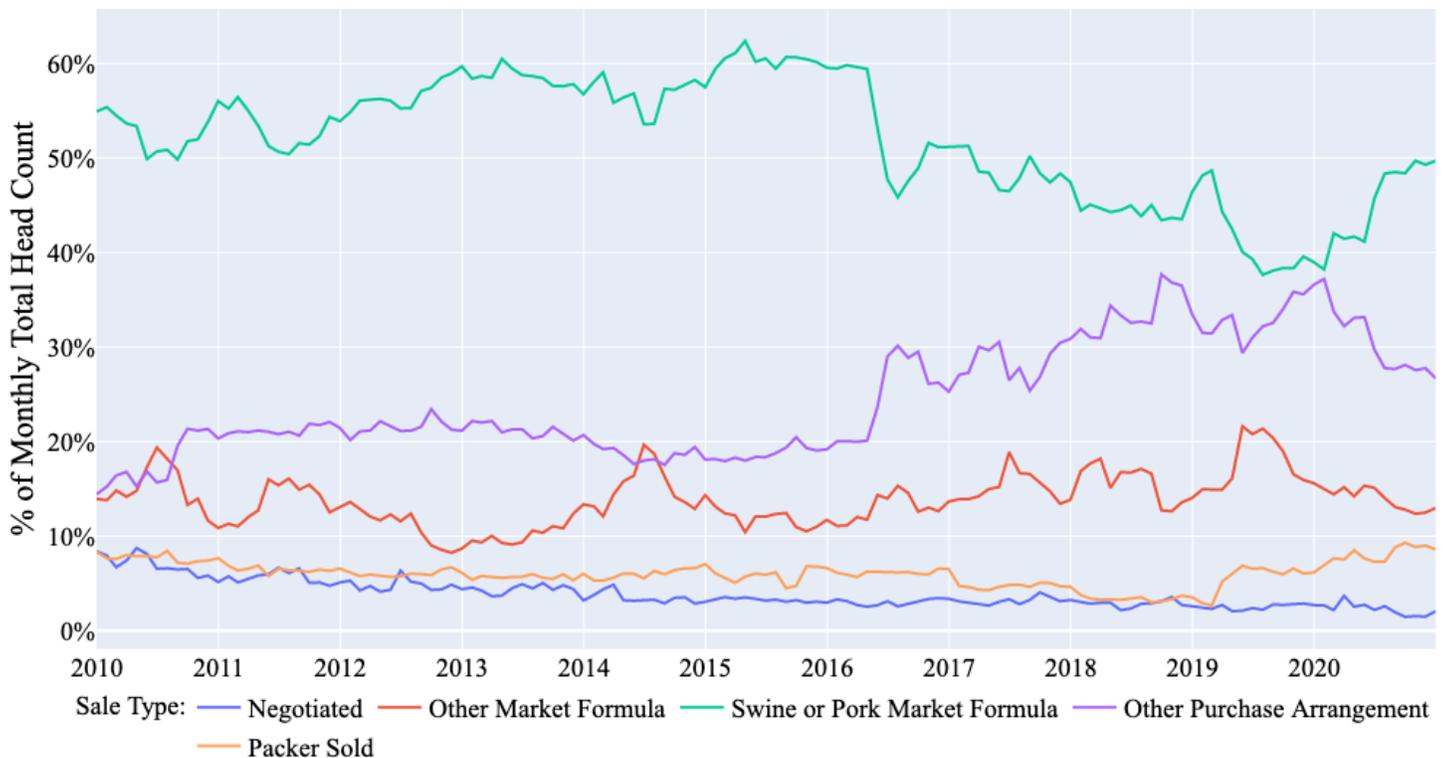


Figure 3. National monthly barrow and gilt head counts.

Data Source: USDA-AMS National Daily Direct Hog Prior Day Report - Average Net Price Distribution (LM_HG215).

Beyond diminished price correlations, there have been two classification changes to SPMF worth noting. In 2017, CME Lean Hog Index-based sales were reclassified from OMF to SPMF. In 2019, CME Pork Cutout Index-based sales were added to SPMF. These classification changes matter because the Lean Hog Index is calculated using SPMF, leading to computational dependence on itself—a feedback loop of sorts. Hog sales based on either the Lean Hog Index (swine sales) or Pork Cutout Index (pork sales) are classified as SPMF sales, which are then used to calculate the Lean Hog Index. Index-based sales are not the only sales included in SPMF. Formulas based on negotiated prices and pork cutouts are common, but exact data on the proportion of these sales in SPMF is not readily available. Whether these classification changes have inherently introduced additional risk is unclear, but it is important to understand that the futures settlement mechanism is interdependent with swine and pork sales.

It is critical for published data to accurately depict the evolving needs of the swine market. A potential corrective mechanism exists for SPMF. Splitting the sale type into separate swine (i.e., Swine Market Formula) and pork (i.e., Pork Market Formula) categories could help realign price correlations, but the subsequent change in the Lean Hog Index calculation could result in adverse conditions for future contracts which are settled using the Lean Hog Index. Specifically, basis would deviate from historical patterns as settlement prices would no longer incorporate pork sales.

Table 5. Price Correlations of Pork Carcass Cutout Value and Negotiated and SPMF Barrow and Gilt Prices, 2013–2020

Year	Pork Cutout-Negotiated Correlation Coefficient	Pork Cutout-SPMF Correlation Coefficient	Negotiated-SPMF Correlation Coefficient
2013	0.919	0.927	0.993
2014	0.973	0.979	0.998
2015	0.801	0.820	0.996
2016	0.835	0.856	0.997
2017	0.926	0.948	0.993
2018	0.855	0.888	0.993
2019	0.590	0.755	0.968
2020	0.255	0.736	0.825

Data Source: USDA-AMS National Daily Pork Report FOB Plant - Negotiated Sales (LM_PK602) and National Daily Direct Hog Prior Day Report - Average Net Price Distribution (LM_HG215).

Annual Net Price Distributions

Weighted average prices and price ranges are useful, but price distributions can aid greatly in price transparency. The *National Daily Direct Hog Prior Day Report - Average Net Price Distribution* (LM_HG215) provides a daily distribution of prices by sale type. In this section, we focus on annual price distributions which illustrate the dispersion of price and volume for all categories of sales.

In the first panel in figure 4, the distribution is representative of an arbitrary year. It is the weighted average of each year’s distribution from 2010–2020 and is relatively normal with a high price tail, largely due to 2014. The second panel in figure 4 shows the distribution for 2014, which had the highest prices from 2010–2020, skews to the right because prices skyrocketed and volumes decreased with the PEDV outbreak. Swine or pork market formula performed the strongest at high price and high volume, as shown by the hump from \$106–\$114. From the definition of SPMF, we can infer that many hogs sold this way are based on negotiated swine prices or the negotiated pork carcass cutout value, both of which saw high prices in 2014 due to tight supplies. The third panel in figure 4 shows the price distribution for 2020, which was largely a price floor for the 2010–2020 period due to the persistence of low prices, though the overall price level does not seem to deviate noticeably from the 2016–2019 trend. Unlike 2014, in 2020 SPMF had more volume at lower prices, and OPA had more volume at higher prices. The 2020 distribution was largely normal, as opposed to 2014, which was right-skewed.

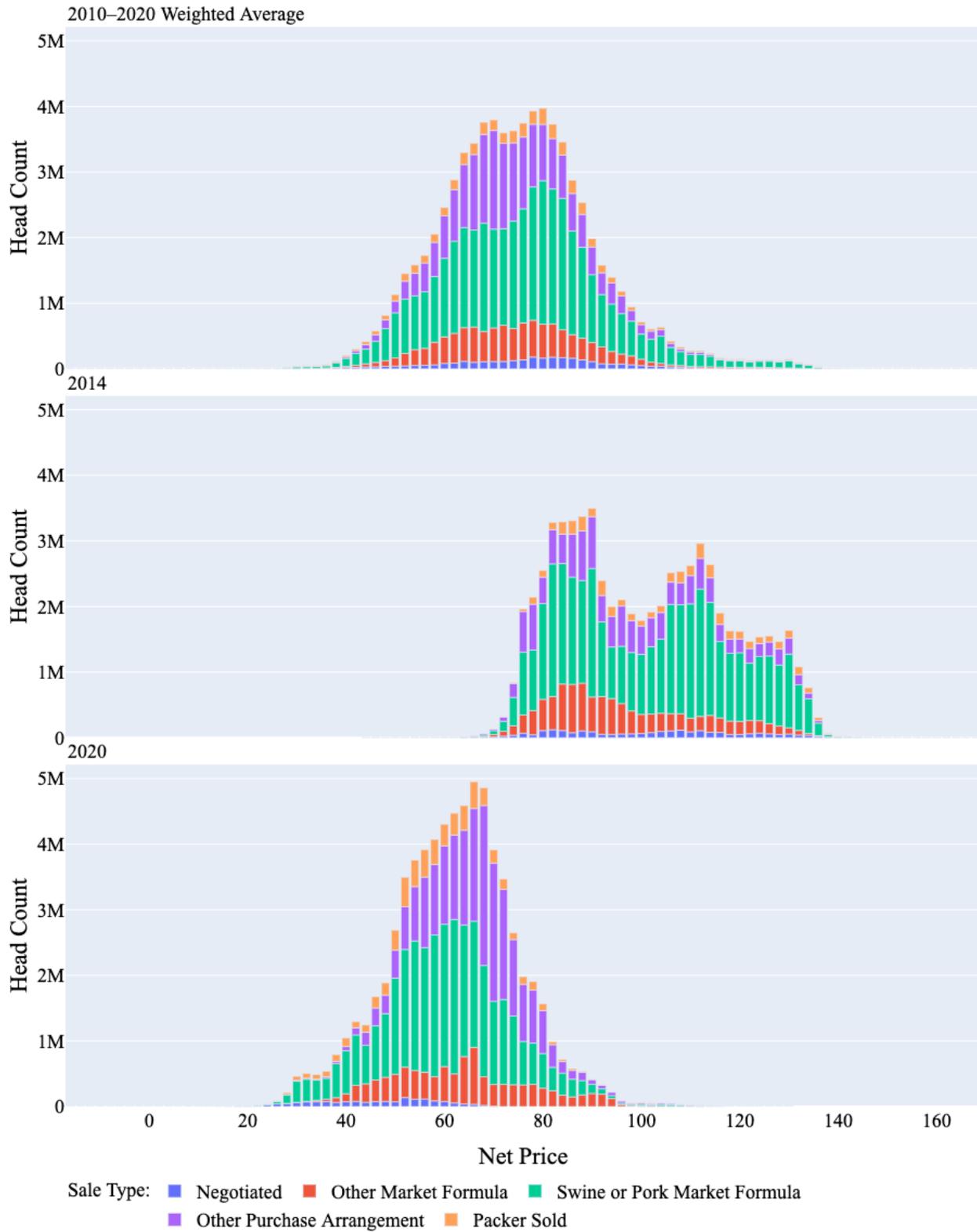


Figure 4. Annual price distributions for barrow and gilt carcass net prices.
 Data Source: USDA-AMS National Daily Direct Hog Prior Day Report - Average Net Price Distribution (LM_HG215).

Quarterly Price Distributions

Figure 5 shows quarterly price distributions. A key takeaway is that prices are lower and more clustered in Q1 and Q4, and higher and more dispersed in Q2 and Q3. Every sale type has its lowest average price in Q4. Each quarter's distribution demonstrates a longer right tail than left. There are two explanations for this. First, taller right tails in Q2 and Q3 are due to anomalously high volume at high prices in 2014. Second, there is an implicit lower bound on prices where it makes sense for producers to bring hogs to market, whereas there is no consistent upper bound on prices because demand is derived from consumer demand passed through packers to producers. When hogs are in short supply, and consumer demand has not abated (e.g., 2014) prices necessarily rise.

Price distributions in figure 4 explain seasonal price dispersions among sale types, but to further reinforce the quarterly volume disparities of each sale type, table 6 shows quarterly head count totals from 2010–2020. Contrary to other sale types, negotiated and OMF are comparatively smaller in Q4 when OPA, SPMF, and packer-sold hogs all post their highest volumes. Notably, quarterly totals for negotiated sales do not fluctuate more than 10% despite having the highest day-to-day variability, as shown in table 3. In all quarters, SPMF is the clear leader, more than doubling the volume of the next closest category.

Table 6. Quarterly Head Count Totals for Barrow and Gilt Sales, 2010–2020

Quarter	Negotiated	Other Market Formula	Swine or Pork Market Formula	Other Purchase Arrangement	Packer Sold	Total
1	7,870,608	26,565,245	105,119,632	47,801,397	11,145,147	198,502,029
2	7,200,900	27,356,878	95,335,174	44,920,362	11,060,500	185,873,814
3	7,394,622	28,379,019	98,729,439	48,322,688	11,614,910	194,440,678
4	7,380,372	26,320,593	107,428,189	52,329,537	13,013,402	206,472,093

Data Source: USDA-AMS National Daily Direct Hog Prior Day Report - Average Net Price Distribution (LM_HG215).

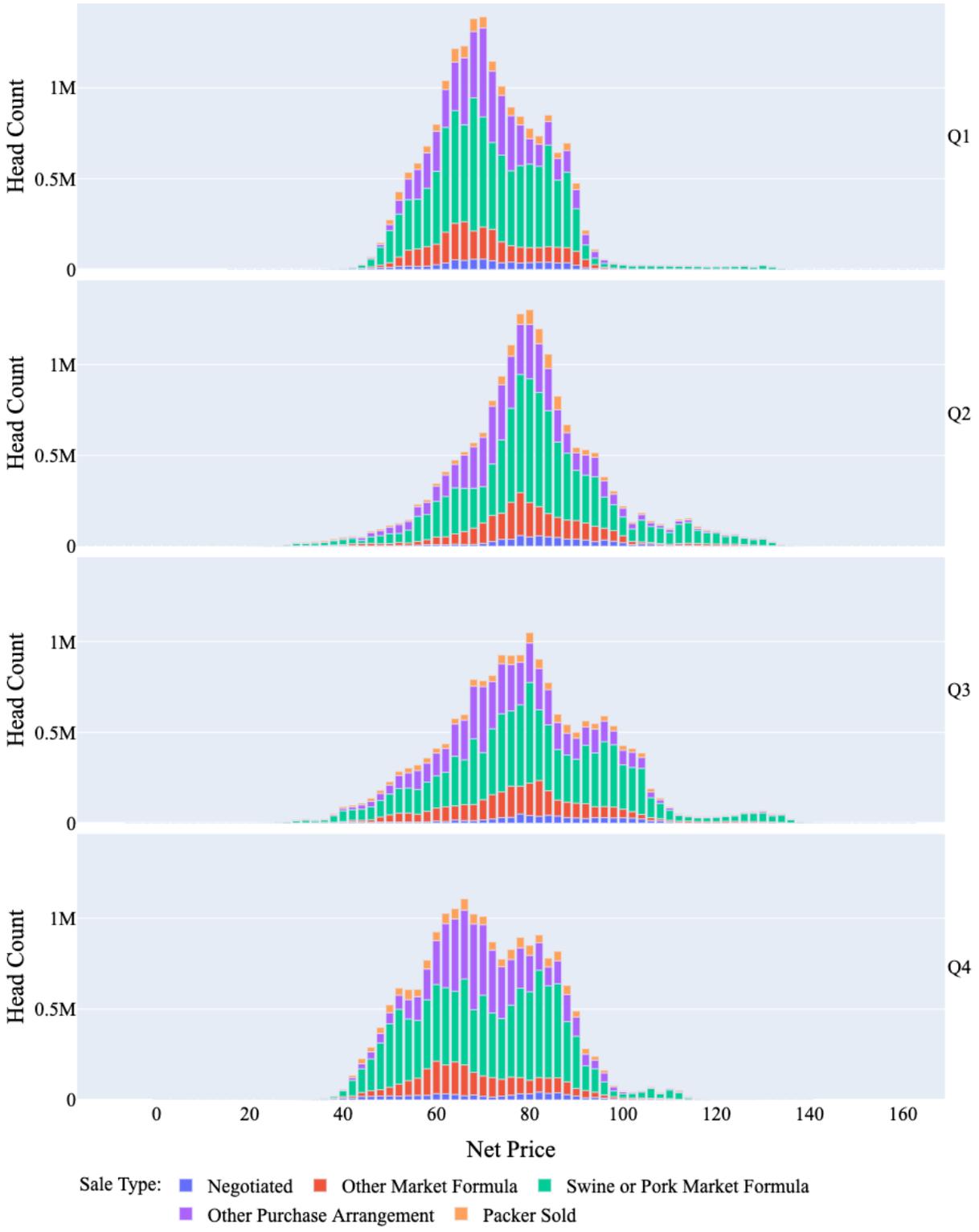


Figure 5. Quarterly weighted average price distributions for barrow and gilt carcass net prices.

Data Source: USDA-AMS National Daily Direct Hog Prior Day Report - Average Net Price Distribution (LM_HG215).

Conclusions

From 2010–2020, there was a continued decline of negotiated sales in both price and volume. In the same span, OPA sales essentially doubled, while SPMF sales largely declined since 2016. Some of this is attributable to changes in sale type classification as well as increased consumer demand for hogs with certain characteristics. Prices were highest in 2014 and lowest in 2020, though coefficients of variation for sale volumes were not drastically different from any other year. The ratio of utilization to capacity is a way to quantify small changes in price. Negotiated, SPMF, and packer sold prices are the most sensitive to changes in utilization, while OMF and OPA are less responsive. Beyond utilization, the marginal cost packers incur can explain extreme prices when hog supply is low or high relative to available capacity. A concerning trend has appeared in price correlations—negotiated swine sales now have a weak correlation with pork cutout values. Eroded correlations and changes in classification of Index-based sales have exposed hedging activity to increased risk, which is an immediate concern for market participants. Yearly and quarterly price distributions tie prices to head counts so that all parties can assess the range of marketing results. All of this demonstrates the importance of LMR published data in addressing marketing issues and providing transparency. By using this public information, stakeholders can have a clearer understanding of past and current market outcomes, more accurately assess risk, and better prepare for future market conditions.