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Nalitra Thaiprasert
Ball State University, nthaiprasert@bsu.edu

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Short-Cut Estimates for Annual Hog CAFO Production: Relationship Between Hog CAFO Inventory and the Annual Production

Abstract
The increasing numbers of hog CAFOs has become a pressing issue around the country, yet estimating the annual hog CAFO production can be a daunting task for local communities. Current accessible information about hog production levels is either complicated or not useful for most interested parties. This article aims to provide a straightforward calculation of annual hog production adjusted to the full-grown hog equivalent based on available inventory data. The calculation could then be applied to the state, county, or farm level, and results easily compared among same-level study areas.

Nalitra Thaiprasert
Research Economist
Office of Building Better Communities
Ball State University
Muncie, Indiana
nthaiprasert@bsu.edu

Introduction

The increasing numbers of hog CAFOs (Concentrated Animal Feeding Operations) around the country has generated interest among local residents and elected leaders in evaluating their preparedness for this influx of livestock operations. The issue has created significant public debate involving the economic opportunities that hog CAFOs could bring to local economies versus their potential problems related to pollution and diseases. County leaders, local economic developers, and some Extension professionals, who have roles in making decisions to restrict or promote the allocation of CAFOs, require specific production and economic information. They need to know exactly how many hogs that area CAFOs could produce annually in order to manage the capacity, taking into account land-use and waste management issues. However, estimating the annual hog production of the area can be a daunting task.

Accessible information about hog production from the USDA (Census of Agriculture) is usually confined to total (crude) numbers of annual inventory and sales. Also, there is no apparent relationship among the values reported in the annual hog inventory to annual hogs sold and the dollar amount of annual sales. This is because the records of the hog sales are usually not classified by the age group of the hogs. For example, one pig at 11-week old sold is counted as one head, as is one full-grown pig sold. This procedure is particularly vexing for analysis of CAFO operations with their high hog throughput.

Other hog production data from the USDA (Agricultural Statistics Board, NASS) are in weight and only available at the state level. These data too, are not helpful for local decision making.

The objective of this article is to provide a method to estimate annual hog production at the full-grown animal equivalent that can be applied to the state, county, or farm level. The proposed method focuses on large hog operations known as CAFOs but can be used for any other size farm regulated by the state in which the annual or monthly inventory records of operations are available by type. The method can provide a straightforward calculation when only the numbers of annual inventory by type of operation are given.

Unlike the data published by the USDA, the estimated results of this method can be compared

among counties or farms for which more relevant information is missing. Because the estimate derived by the proposed method is in the same unit (full-grown hog equivalent), taking into account only stages that are grown locally, it avoids the confusion of in-shipment and out-shipment data, which are also not classified by age group. Thus, this method can provide a ready-to-use, easily comparable, but reliable estimation of hog production.

Methodology

This article used hog inventory data by type of operation and county for hog CAFOs and CFOs (Confined Feeding Operations) in Indiana. The data was acquired from the Indiana Department of Environmental Management (IDEM) for CAFO issued permits, which provided monthly and annual inventories of hog operations with 600 head and above classified into three types of operations (or three stages of production): sow units (piglets from birth up to 3 weeks old), nurseries (nursery pigs at 3-11 weeks old), and finishers (11-week to full-grown at 26-week old). The first and second stages are very labor-intensive and require more full-time workers than the third stage.

Samples used for this analysis are 210 cases of 75 Indiana counties that have had changes in hog CAFO/CFO inventory between 2001-2006.

Based on previous studies of hog production costs by many university Extension professionals, major assumptions used in the estimation are:

1. A nursery pig is worth 1/3 of a full-grown pig (a 50-lb-nursery pig is sold around $42, a 265-lb-finishing pig is sold around $119; Plain, 2007).

2. A piglet is worth 1/10 of a full-grown pig (author's estimate by using relative weight (13-lb at 3-week) to a nursery pig).

3. One sow is counted as one full-grown pig.

4. One sow has two litters per year with an average of 8.9 piglets per litter; thus, the estimate of piglets per sow per year is 17.8 head (simplified annual average of Indiana, data from the NASS, USDA).

5. A nursery can have up to 4.7 cycles per year to produce nursery pigs (52-week ÷ 11-week = 4.7 cycles).

6. A finishing operation can have up to 2.7 cycles per year to produce finishing pigs (according to interviews with owners of finishers).

7. Every piglet will be shipped to nurseries in the county first, the rest will be exported. Same rule applies to shipment of nursery pigs to finishers.

8. The number of pigs raised by finishers is subtracted from the number of pigs raised by the county nurseries. This avoids the plague of double-counting for the full-grown equivalent. Likewise, care should be exercised to avoid double counting of piglets and nursery pigs.

Results and Discussion

Results of 210 samples allow us to draw the conclusion that there are four types of hog production found at county level.

Type 1: Importing piglets and nursery pigs (65 samples)

Type 2: Exporting piglets and nursery pigs (35 samples)

Type 3: Exporting piglets, importing nursery pigs (98 samples)

Type 4: Importing piglets, exporting nursery pigs (12 samples)

The averages of hog production cycles of each hog production type using the **combined (crude) inventory** of piglets, nursery pigs, and finishing pigs in a study area (county) are as follows.

Type 1: 1.69 cycles, Standard deviation 0.021

Type 2: 1.76 cycles, Standard deviation 0.175

Type 3: 1.75 cycles, Standard deviation 0.074

Type 4: 1.61 cycles, Standard deviation 0.065

Average of all types: 1.7 cycles

Results of various combinations of hogs produced at the county level show a very consistent range of cycles between 1.61-1.76 per year, or an average of 1.7 cycles per year. Thus, an Extension professional could easily estimate the number of hog production at the full-grown equivalent in a county by applying the appropriate number of cycles to the crude hog inventory number in the county. For an even more simplified method, the average value of 1.7 could be used instead.

Only the average cycle of Type 4 (1.61) has a large deviation from 1.7; however, the chance that a county has primarily Type 4 hog production is relatively low. Only 5.7% of the 210 samples fall in to Type 4 production.

Below are examples of calculation tables for each type of hog production based on the real data.

Type 1: Importing Piglets and Nursery Pigs

Table 1.
Jay County, Indiana (Thaiprasert & Heupel, 2007a)

		1	2	3	4
	2006 Inventory	**Sows**	**Nursery Pigs**	**Finishers**	**Total**
A	Total inventory (head)	5,501	39,265	173,421	**218,187**
B	Cycle	1	4.70	2.70	
C	Total production (head) (A x B)	**5,501**	184,546	468,237	**658,283**
D	Piglets per sow per year (head)	17.80			
E	Total piglets produced (C1 x D1)	97,918			
F	Piglets imported into County by nurseries (C2 - E1)		86,628		
G	Deduct piglet value out of above nursery pigs by 1/10 of full-grown hog value (0.9 x F2))		77,965		
H	Pigs grown in County from birth to finishing and from nursery to finishing (E1 + G2)		**175,883**		
I	Finishing pigs from imported 11-week pigs (C3 - H2)			292,354	
J	Finishing pigs at reduced value 2/3 of full-grown hog due to import of 11-week pigs (2/3 x I3)			**194,903**	
K	Total annual hog production from CFOs/CAFOs at full-grown equivalent (head)	**5,501**	**175,883**	**194,903**	**376,286**
Using the simplified estimation: 218,187 x 1.7 = 370,918 head					

Type 2: Exporting Piglets and Nursery Pigs

Table 2.
Randolph County, Indiana (Thaiprasert & Heupel, 2007b)

		1	2	3	4
	2006 Inventory	**Sows**	**Nursery Pigs**	**Finishers**	**Total**
A	Total inventory (head)	29,646	67,420	89,750	**186,816**
B	Cycle	1.00	4.70	2.70	
C	Total production (head) (A x B)	**29,646**	316,874	**242,325**	**558,845**
D	Piglets per sow per year (head)	17.80			
E	Total piglets produced (C1 x D1)	529,699			
F	Piglets exported out of County	210,825			

	(E1 - C2)				
G	Exported piglets at 1/10 of full-grown hog value (0.1 x F1)	**21,082**			
H	Total nursery pigs exported (C2 - C3)		74,549		
I	Exported nursery pigs as 1/3 of full-grown hog (1/3 x H2)		**24,850**		
J	Total annual hog production from CFOs/CAFOs at full-grown equivalent (head)	**50,728**	**24,850**	**242,325**	**317,903**
Using the simplified estimation: 186,816 x 1.7 = 317,587 head					

Type 3: Exporting Piglets, Importing Nursery Pigs

Table 3.
White County, Indiana

		1	2	3	4
	2006 Inventory	**Sows**	**Nursery Pigs**	**Finishers**	**Total**
A	Total inventory (head)	13,615	41,373	159,318	**214,306**
B	Cycle	1	4.70	2.70	
C	Total production (head) (A x B)	**13,615**	**194,453**	430,159	**638,227**
D	Piglets per sow per year (head)	17.80			
E	Total piglets produced (C1 x D1)	242,347			
F	Piglets exported out of County (E1 - C2)	47,894			
G	Exported piglets at 1/10 of full-grown hog value (0.1 x F1)	**4,789**			
H	Finishing pigs from imported 11-week pigs (C3 - C2)			235,706	
I	Finishing pigs at reduced value 2/3 of full-grown hog due to import of 11-week pigs (2/3 x H3)			**157,137**	**157,137**
J	Total annual hog production from CFOs/CAFOs at full-grown equivalent (head)	**18,404**	**194,453**	**157,137**	**369,994**
Using the simplified estimation: 214,306 x 1.7 = 364,320 head					

Type 4: Importing Piglets, Exporting Nursery Pigs

Table 4.
Daviess County, Indiana

		1	2	3	4
	2006 inventory	**Sows**	**Nursery Pigs**	**Finishers**	**Total**
A	Total inventory (head)	5,043	25,340	38,797	**69,180**
B	Cycle	1	4.70	2.70	
C	Total production (head) (A x B)	**5,043**	119,098	104,752	**228,893**
D	Piglets per sow per year (head)	17.80			
E	Total piglets produced (C1 x D1)	89,765			
F	Piglets imported into County by nurseries (C2 - E1)		29,333		
G	Deduct piglet value out of above nursery pigs by 1/10 of full-grown hog value (0.9 x F2)		26,399		

H	Pigs grown in County from birth to finishing and from nursery to finishing (E1 + G2)		116,165		
I	Total nursery pigs exported (H2 - C3)		11,413		
J	Exported nursery pigs as 1/3 of full-grown hog (1/3 x I2)		3,804		
K	Pigs grown in County after exporting (C3 + J2)		**108,556**		
L	Total annual hog production from CFOs/CAFOs at full-grown equivalent (head)	**5,043**	**108,566**	**0**	**113,599**
Using the simplified estimation: 69,180 x 1.7 = 117,606 head Using the average Type 4 cycles: 69,180 x 1.61 = 111,380 head					

An Extension professional can get a more accurate estimate of the hog production in the county by replacing the inventory numbers in row A of each table. The table that does not contain any negative numbers after replacing the inventory numbers is the table that could be used.

Robustness of Estimation

To test the robustness of the estimation, results of hog production by state, calculated by the proposed method, are compared against the USDA's state data, which have to be in the same unit. As mentioned before, the USDA's data on hog production by head is not classified by age group, thus, one way to compare the results is to convert the USDA's crude hog inventory into the full-grown hog equivalent and then into the production weight (because the USDA publishes annual total hog production by weight).

To do this, the USDA's crude annual hog inventory is multiplied by 1.7 to acquire the full-grown equivalent of annual hog production by head. The full-grown equivalent number is then multiplied by 265 to convert it into the annual production weight at 265 pounds per one full-grown hog. The final result in weight is compared against the USDA's published data as shown in the last column of Table 5. Samples used in this test are of the 50 states plus the U.S. for 7 years (2000-2006), which are equal to 357 samples.

Table 5.
Robustness Test, Selected States in 2006

	USDA Published Data		**Estimation**		
	A	**B**	**C = A x 1.7 cycles**	**D = C x 265**	**(D-B)/B**
	Total Hog Inventory	**Production**	**Full-grown equivalent Production**	**Production**	**Difference**
State (2006)	**(1,000 head)**	**(1,000 pounds)**	**(1,000 head)**	**(1,000 pounds)**	
Alabama	165	75,336	281	74,333	-1.3%
Arizona	148	64,284	252	66,674	3.7%
Arkansas	260	117,493	442	117,130	-0.3%
California	145	68,869	247	65,323	-5.1%
Florida	20	8,445	34	9,010	6.7%
Idaho	25	11,100	43	11,263	1.5%
Indiana	3,350	1,493,946	5,695	1,509,175	1.0%
Iowa	17,300	8,211,548	29,410	7,793,650	-5.1%
Kansas	1,840	800,856	3,128	828,920	3.5%
Maryland	33	15,612	56	14,867	-4.8%
Michigan	1,000	480,183	1,700	450,500	-6.2%
Minnesota	6,900	3,337,839	11,730	3,108,450	-6.9%
Mississippi	335	150,522	570	150,918	0.3%
Missouri	2,800	1,294,070	4,760	1,261,400	-2.5%
Nebraska	3,050	1,411,215	5,185	1,374,025	-2.6%

Oregon	25	11,526	43	11,263	-2.3%
Pennsylvania	1,080	481,461	1,836	486,540	1.1%
Tennessee	220	92,314	374	99,110	7.4%
Wisconsin	450	219,018	765	202,725	-7.4%
United States	**62,490**	**28,140,468**	**106,233**	**28,151,745**	**0.0%**

Percentages of accuracy of the robustness test are shown by range in Table 6. As high as 66% of test samples have an estimated annual hog production weight whose results differ from the USDA's published data by only ±20%, and 22% of these test samples have only a ±5% difference, which is a very narrow range. 11% of samples yield a large difference of ±50% and higher, which may be caused by several factors. First is the application of the average 1.7 cycles of production in some states, which could be more sensitive than others, instead of applying the number of any specific type cycle. Second, which could cause a bigger impact, is from the discrepancy in the USDA's data collection. For example, the total inventory of Arizona in 2000 was reported at 9,000 head, reduced from 140,000 head in 1999, while total production was reported at 59,798,000 pounds, or 335,000 crude head. Similar discrepancies also happen to data for Alabama, Arkansas, Connecticut, Delaware, Louisiana, Nevada, New Jersey, New York, Massachusetts, Texas, Virginia, and West Virginia. It should be noted that all of these states do not have large hog sectors.

However, estimates at the national level produced very high accuracy as for all 7 years samples of the U.S. had differences of less than 4%. States that had high to very high accuracy over 7 years are California, Indiana, Iowa, Kansas, Minnesota, Missouri, Montana, Nebraska, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, South Dakota, Wisconsin, and Utah. This would suggest that states that have higher accuracy (less than ±20% difference) could use the proposed method more comfortably to estimate their local hog production.

Table 6.
Accuracy of Robustness Test

Range of Difference	**Samples**	**Percent**
±0.0-5.0 % (more accurate)	78	22%
±5.1-10.0 %	72	20%
±10.1-15.0 %	46	13%
±15.1-20.0 %	38	11%
±20.1-25.0 %	28	8%
±25.1-30.0 %	21	6%
±30.1-35.0 %	14	4%
±35.1-40.0 %	12	3%
±40.1-45.0 %	3	1%
±45.1-50.0 %	6	2%
±50.1 % and higher (less accurate)	39	11%
Total	**357**	**100%**

Implications for Extension

The calculation method derived from this research creates a direct relationship between annual inventory and annual production at the full-grown hog equivalent. This method can be used to project future hog production to aid a county in land-use issues surrounding potential CAFO establishments. Moreover, the method allows users to compare hog production levels based on the same unit of measurement among various counties without facing many calculation struggles.

To fully estimate hog production of a county for other purposes, such as converting the inventory into a dollar figure of county annual output, one has to take into account the inventory of small hog farms, which have been in a sharp decline. Thus, the calculation will prove to be even more useful when the hog production industry has become more integrated (McBride & Key, 2003; Haley, 2004).

The 1.7 cycle number can be applied not only at the county level, but also at the state and farm levels if a state or farm produces more than one kind (age) of hog. If a farm only produces one kind of hog, applying direct annual cycles (17.8 for piglets per sow, 4.7 for nursery pigs, and 2.7 for finishing pigs) should provide more accurate results.

Future studies should quantify the relationship between labor income and the four types of hog production. The preliminary assumption is that hog operations that concentrate on the production

of piglets and nursery pigs result in higher labor income to the county because they are more labor intensive than finishing operations. Moreover, the labor-intensive operations tend to hire more full-time workers than the capital intensive ones. A concentration of sow units and nursery farms in a county can lead to higher earnings per worker for the hog production sector in the county when compared to a county with concentrated finishing hog operations. If the assumption is proven correct, it may influence the selection or promotion of a certain type of hog operations to be located in a county.

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