Applications of Quarterly Livestock Models in Evaluating and Revising Inventory Date

by

Bruce Blanton, S. R. Johnson, Jon A. Brandt,

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1. Introduction

Inventory data are important leading indicators for the livestock industry in the U.S. These data are reported semi-annually by the USDA for major livestock commodities and have been developed on this basis since 1954. Over the period since 1954, changes in these inventory data have been made, largely related to coverage of states and procedures for revision. They remain, however, key indicators to the trade since they signal or reflect build-ups and subsequent implications for market prices, production levels and margins at the various levels in the production and marketing chain.

The importance of these inventory data to the livestock industry and market has resulted in continuous efforts by the USDA to improve them. However, because they are self-reported by sampled producers and their impacts on marketings are delayed by the natural production process, they are difficult to verify on a timely basis. Simply put, errors in inventory estimates only become generally known when livestock marketings, which occur after any additions or reductions in inventories, are shown to be inconsistent with the earlier herd size.

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In 1954, published estimates of inventory numbers by calendar quarter had begun for six states--Indiana, Illinois, Wisconsin, Minnesota, Iowa, and Kansas (USDA, 1979). Ohio, Missouri and South Dakota were added in 1956 and Nebraska in 1957. The ten corn belt states were sampled quarterly through 1973. Beginning in March, 1974, four more states were added--North Carolina, Georgia, Kentucky, and Texas. Production in these additional states reflected a moderate shift away from the corn belt toward the south, and particularly the southeast during the 1960s. Sampling was reduced to 23 individual states for the June Hogs and Pigs reports during this period.

Beginning with June 1, 1982, coverage in the June Hogs and Pigs report was reduced from 23 states to 10 states--Ohio, Indiana, Illinois, Minnesota, Iowa, Missouri, Nebraska, Kansas, Georgia, and North Carolina--plus a composite estimate for 40 other states and the U.S. total. Beginning with September 1, 1982, coverage of the September and March reports was reduced from 14 to the above-mentioned 10 states. Only the December report continues to provide inventory levels for all 50 states.

A casual review of "revised or final estimate" reports[1] over the 1930-1982 period suggests that, in general, revisions were relatively

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The estimation of numbers of hogs and pigs on farms in states is generated from two sources: 1) a list frame constructed from various sources consisting of producers who raise hogs and 2) an area frame (an exhaustive listing of small partitioned units of land) (USDA, 1979). A random stratified hog sample is selected from the list by state office for each survey. The area frame represents those hog producers not on the list. The area frame survey segments include about one-half of 1 percent of the U.S. land area. The sample of land segments is supplemented by lists of large hog producers in each state. The large producers are sampled at a higher rate to reflect their relative importance in the industry for their area.

The sampling rate is nearly five percent of the producers at the U.S. level. The average survey collects sample data equal to about ten percent of the estimated population, because the sample rate increases as size of operations increases. The size of the sample depends to an extent on available resources, level of detail required in the statistical estimates, precision required, variability of data being sampled, and size of the population. In recent surveys, the sampling variability, as measured by the relative standard error, has been about two percent. This means that in a repeated sample context, approximately 95 out of 100 survey estimates would have been within four percent of the complete coverage value if the same procedure were used to survey all producers. Survey estimates are also subject to non-sampling errors such as omission, duplications, and mistakes in reporting, recording, and processing the data; however, efforts are made to minimize these.

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Farm Supply Equations

The farm supply block of the pork model consists of six equations: additions to the breeding herd (ABH), sow slaughter (SS), breeding herd inventory (BHI), pig crop (PC), barrow and gilt slaughter (BGS), and pork produced at the farm level (PPF). These equations were estimated using biological restrictions reflecting the growth and reproductive processes for hogs. Parameter estimates in the equations that are presented without the t-values (in parentheses) were developed using biological hypotheses and the sample data. The estimated equations are

$$\begin{aligned} ABH_t = {} & (.0461D1_t + .0433D2_t + .0794D3_t + .0342D4_t - .0085TDM1_t \\ & - .0433TDM2_t + 16.8144DM1_t + 16.5899DM2_t)PC_{t-2} \\ & + \underset{(1.76)}{9.8170}(BGMP7C_t/CORPF_t) - \underset{(-2.46)}{34.3845}IFCL_t \\ & + \underset{(2.20)}{.0107}DMPC_t , \end{aligned} \qquad (1)$$

$$\begin{aligned} SS_t = {} & (.1144D1_t + .1169D2_t + .1376D3_t + .1536D4_t - .0019TDM1_t \\ & - .0101TDM2_t - .0032TDM3_3 + 3.7471DM1_t + 20.0006DM2_t \\ & + 6.2929DM3_t)BHI_{t-2} - \underset{(3.45)}{6.4657}(BGMP7C_t/CORPF_t) \\ & + \underset{(3.26)}{11.4191}IFCL_t , \end{aligned} \qquad (2)$$

$$BHI_t = BHI_{t-1} + ABH_t - SS_t , \qquad (3)$$

$$PC_t = (2.1225D1_t + 3.1091D2_t + 2.4660D3_t + 2.5173D4_t)BHI_t , \qquad (4)$$

$$BGS_t = (.8861D1_t + .8802D2_t + .9690D3_t + .7333D4_t)PC_{t-2} , \qquad (5)$$

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where $P1_t$ is the retail price of pork, $P2_t$ is the retail price of beef, $P3_t$ is the retail price of chicken, $P4_t$ is the retail price of fish, $P5_t$ is the price index for other goods, and M_t is per capita income.

The process for determining derived retail supply was to relate marketed product (X_{st}) to farm level production (PPF_t). The equation determining the quantity margin is as follows

$$X_{st} = PPF_t'/\hat{k}_t \tag{8}$$

where $PPF_t' = (PPF_t/1000)$ (this transforms farm and retail level units into the same scale), the $\hat{k}$ are the farm to retail transformation ratios, and X_{st} denotes the derived retail quantity supplied.

The relationship between the retail and farm level price for the quarterly pork model was determined using a margin equation. Specifically,

$$\begin{aligned} MARGIN_t = &\underset{(2.86)}{5.3379D1_t} + \underset{(2.47)}{4.6102D2_t} + \underset{(2.12)}{4.0488D3_t} + \underset{(3.85)}{6.9752D4_t} \\ &+ \underset{(19.42)}{8.2493WR_t} + \underset{(9.89)}{0.6655BGMP7C_t} \quad R^2 = .99 \quad D.W. = 1.35 \end{aligned} \tag{9}$$

where $MARGIN_t$ represents the difference between the retail and farm level price, $D1_t$, $D2_t$, $D3_t$, and $D4_t$ are seasonal dummies, WR_t denotes the wage rate of meat packing plant workers and, again, $BGMP7C_t$ is the farm level price for hogs. This equation was estimated using ordinary least squares. The marketing margin equation was utilized in the quarterly pork model to solve for the farm level price, BGMP7C.

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5. Evaluation of Inventory and Additions Data

While reports of barrow and gilt slaughter are considered accurate and can be validated, as previously indicated the estimates on the percentage of slaughtered gilts are derived. Without short-term information on actual slaughter, there is no apparent way to improve quarterly data on the breeding herd. Information on slaughter by sex is usually viewed as unavailable due to its proprietary nature. Given that accurate, detailed information on the breeding herd composition is difficult to attain, it is important to identify possible errors in the USDA breeding herd inventory estimates using alternative methods. The method used in this section for making these corrections is based on the biological structure in the supply component of the pork model.

The technical and institutional information in the supply component of the econometric model was utilized for estimating breeding inventory retrospectively. The supply component of the model was viewed as applicable for this purpose because of the restrictions assuring biological consistency. That is, the supply component of the hog model is conditioned by relationships between the breeding herd inventory and the barrow and gilt slaughter numbers. It is presumed that biological processes and exogenous prices determine slaughter numbers based on the size of the breeding herd. If the breeding herd inventory is constant (implying additions to the breeding herd equal sow slaughter), then total slaughter is constant. If the breeding inventory increases, then slaughter decreases in the short run. Alternatively, if the breeding herd changes by a certain percentage,

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Table 1

PERCENTAGE CHANGE IN BREEDING HERD INVENTORY TO BARROW AND GILT SLAUGHTER WITH A TWO QUARTER LAG

Breeding Herd Inventory Year/Quarter	Percentage Change From Four Quarters Earlier	Barrow and Gilt Slaughter Year/Quarter	Percentage Change From Four Quarters Earlier	Percentage Difference in Breeding Herd and Slaughter
1966-1	0.710	1966-3	1.495	0.785
1966-2	8.418	1966-4	16.640	8.222
1966-3	10.575	1967-1	21.950	11.375
1966-4	8.206	1967-2	10.103	1.897
1967-1	7.758	1967-3	11.601	3.843
1967-2	2.266	1967-4	4.739	2.473
1967-3	2.697	1968-1	-0.976	-3.672
1967-4	4.639	1968-2	9.583	4.944
1968-1	3.656	1968-3	5.595	1.939
1968-2	-0.704	1968-4	4.328	5.032
1968-3	2.937	1969-1	4.139	1.202
1968-4	4.859	1969-2	-0.183	-5.043
1969-1	3.113	1969-3	-1.780	-4.894
1969-2	-0.338	1969-4	-8.868	-8.529
1969-3	-0.508	1970-1	-9.589	-9.081
1969-4	-3.247	1970-2	-1.562	1.686
1970-1	-2.988	1970-3	3.382	6.370
1970-2	4.616	1970-4	19.073	14.457
1970-3	15.481	1971-1	20.734	5.253
1970-4	14.462	1971-2	17.611	3.149
1971-1	4.962	1971-3	9.571	4.608
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Table 1--Continued

Breeding Herd Inventory Year/Quarter	Percentage Change From Four Quarters Earlier	Barrow and Gilt Slaughter Year/Quarter	Percentage Change From Four Quarters Earlier	Percentage Difference in Breeding Herd and Slaughter
1971-3	-8.297	1972-1	-7.817	0.481
1971-4	-8.308	1972-2	-8.582	-0.274
1972-1	-12.131	1972-3	-12.574	-0.443
1972-2	-7.847	1972-4	-10.947	-3.100
1972-3	-6.165	1973-1	-9.891	-3.726
1972-4	-2.632	1973-2	-8.888	-6.256
1973-1	2.065	1973-3	-13.711	-15.776
1973-2	-0.170	1973-4	-5.963	-5.792
1973-3	-1.738	1974-1	-0.325	1.414
1973-4	0.422	1974-2	7.584	7.162
1974-1	-0.520	1974-3	14.314	14.835
1974-2	0.284	1974-4	1.496	1.212
1974-3	-1.836	1975-1	-6.232	-4.396
1974-4	-8.937	1975-2	-15.027	-6.090
1975-1	-14.131	1975-3	-20.048	-5.917
1975-2	-18.879	1975-4	-18.113	0.765
1975-3	-16.604	1976-1	-6.242	10.362
1975-4	-11.361	1976-2	-4.445	6.916
1976-1	2.504	1976-3	19.219	16.716
1976-2	11.378	1976-4	29.097	17.709
1976-3	13.998	1977-1	11.548	-2.450
1976-4	13.436	1977-2	10.147	-3.288

Table 1--Continued

Breeding Herd Inventory Year/Quarter	Percentage Change From Four Quarters Earlier	Barrow and Gilt Slaughter Year/Quarter	Percentage Change From Four Quarters Earlier	Percentage Difference in Breeding Herd and Slaughter
1977-1	5.770	1977-3	0.780	-4.990
1977-2	3.798	1977-4	-5.317	-9.115
1977-3	3.577	1978-1	-1.750	-5.326
1977-4	4.812	1978-2	2.037	-2.776
1978-1	7.402	1978-3	2.003	-5.400
1978-2	-1.135	1978-4	-0.530	0.605
1978-3	1.945	1979-1	3.862	1.917
1978-4	5.419	1979-2	16.458	11.039
1979-1	11.634	1979-3	17.558	5.924
1979-2	20.606	1979-4	22.748	2.142
1979-3	17.060	1980-1	20.4797	3.4197
1979-4	10.192	1980-2	11.9962	1.8043
1980-1	0.521	1980-3	-0.0520	-0.5726
1980-2	0.233	1980-4	-1.5774	-1.8104
1980-3	-8.555	1980-1	-2.1872	6.3679
1980-4	-9.178	1981-2	-9.5453	-0.3673
1981-1	-5.251	1981-3	-3.2183	2.0329
1981-2	-12.165	1981-4	-2.0573	10.1080
1981-3	-11.845	1982-1	-8.8555	2.9898
1981-4	-6.225	1982-2	-8.0714	-1.8466

have gained enough weight to be slaughtered. Thus, pigs born in quarter i are normally ready for slaughter in quarter i+2.

By studying Table 1 it can be observed that USDA percentage changes in breeding herd inventory estimates differ substantially from lagged slaughter estimates. Greatest differences occur in 1966 third quarter, 1970 second quarter, 1973 first quarter, 1974 first quarter, 1976 first and second quarters and 1978 fourth quarter. These differences were 11.375, 14.457, -15.776, 14.835, 16.716, 17.709 and 11.039, respectively. Certainly these large differences can be attributed to more than the changing composition of the herd. It is highly unlikely that the breeding herd would either increase or decrease by eleven to seventeen percent within one quarter. Thus, these differences likely reflect errors in the breeding herd inventory data. It now becomes apparent why the additions to the breeding herd equation in Section 4 did not perform as well as the other inventory supply equations. The model was possibly generating more accurate estimates than were provided by the data.

Figure 1 shows the estimated percent of error in breeding herd inventory accounts. The vertical reference line at zero marks agreement of the USDA estimate and the biologically-implied estimate. Points most distant from this reference indicate the most disagreement. Figure 2 shows actual values of the USDA inventory numbers versus the inventory numbers implied by biology and observed barrow and gilt slaughter values. More than likely, the real breeding herd inventory numbers were somewhere between the two.

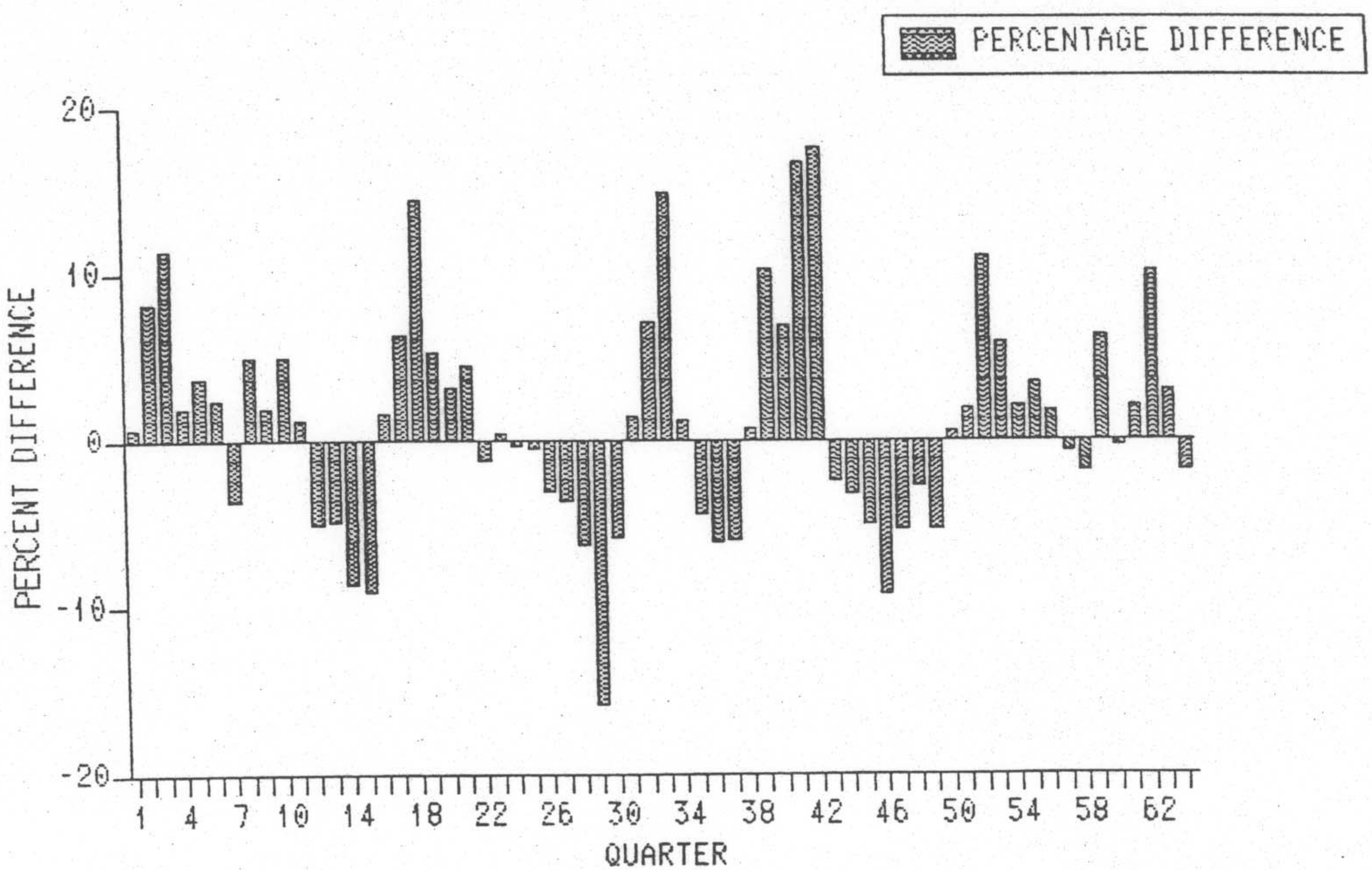

Figure 1

Percent difference between USDA breeding herd inventory data and breeding herd data derived from biological relationships

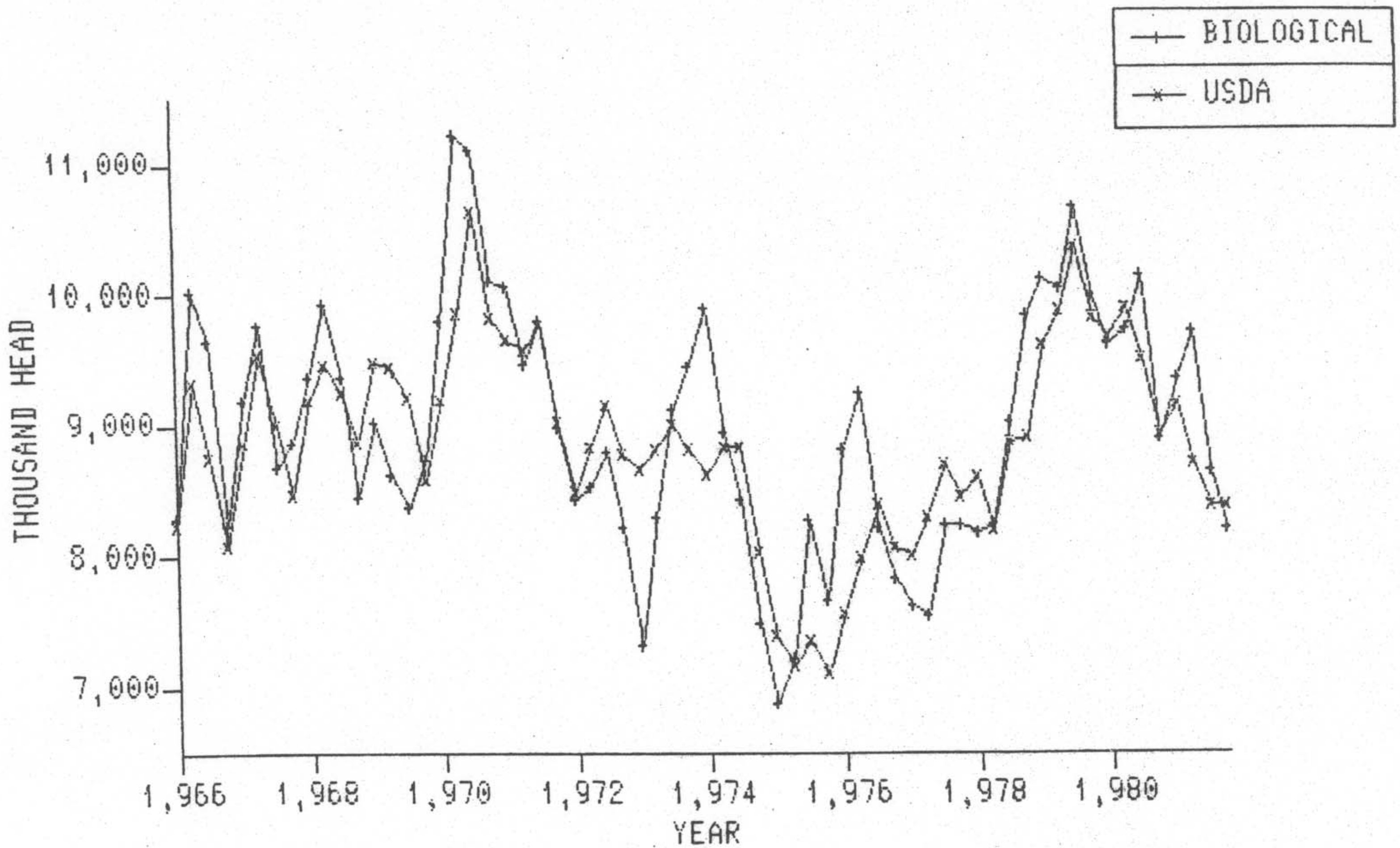

Figure 2

USDA vs. biological estimates of breeding herd inventory
(abstracting from additions or deletions to breeding herd)

6. Conclusion

The intent of this paper has not been to fault present methods of collecting and processing the USDA figures. Clearly, unless sex of slaughtered animals becomes available or the surveys become more comprehensive, the problem with the additions data and thus herd or inventory estimates will remain. Instead, the intent has been to suggest that econometric models with strong biological restrictions on the supply side can be used to augment and improve the estimation and revision procedures for the inventory data. In particular, the econometric model provides a way of processing observed marketings data more systematically for estimating adjustments. The time series comparisons in Section 6 suggest if anything that there has been over-shooting in the estimation of breeding herd inventories. The discipline and structure of the model, utilizing not only marketings but also prices and, thus, more information on trade perceptions, would appear to have potential for improving the accuracy and responsiveness of inventory estimates to past and present survey, marketings, and price level data.

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