

Sampling Considerations for Livestock Surveys

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Abstract

Recently, the importance of livestock statistics is increasing because of the food consumption pattern in Korea is changing. We compare the old sample design based on the 1995 National Agriculture Census with the new sample design based on the 2000 National Agriculture Census. We present some considerations to improve the efficiency of the sample design in livestock sector survey.

Keywords : Livestock survey, Sample design, National Agriculture Survey.

1. Introduction

The "Livestock Statistics Survey" is to find out number of households breeding livestock and number of head of livestock. The statistics for Korean cattle, beef cattle, dairy cows, pigs, and chickens, which are the leading items of livestock industry in Korea, is very important for making livestock industry policy because the statistics directly affect the livestock policy in such areas as price stabilization, and increased production.

The livestock is classified into two components:

- 1) Main livestock : Korean cattle, beef cattle, dairy cows, pigs, and chickens.
- 2) Minor livestock : all livestock and poultries except the livestock in the main livestock.

The current "Livestock Statistics Survey" conducts to get the information about the breeding livestock status for five main items, Korean cattle, beef cattle, dairy cows, pigs, and chickens. This survey is carried out using both the take-all survey and sample survey. Take-all survey is complete enumeration of large farm. The livestock sample survey is conducted four times (March, June, September, and December) a year for 15 days and the statistics on minor livestock is collected twice a year (June, December) through local administrative channels.

The latest "Livestock Statistics Survey" was conducted in March 2003 in Korea. In October 2002, the Ministry of Agriculture and Forestry revised its sampling frame based on the 2000

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agriculture census results. The sample frame was changed fourtimes in the years of 1985, 1993, 1998, and 2002, from the initial 1974 one. We will consider the sampling aspects in this survey. Using the new sample design, it published the results of the survey in March 2003 on the "Livestock Statistics" book published by the government and on the internet (http://www.naqs.go.kr/html/05_04_02.htm). The following explains step by step the method of the new sample design for livestock survey.

2. New Sample Design for Livestock Statistics Survey of March 2003

First is a brief summary of the differences between the previous sample design which is based on 1995 Agricultural Census, and the new sample design, which is based on 2000 Agricultural Census. Once 42,916 Enumeration Districts (ED) of Agricultural Census are divided into 2 ~18 strata according to characteristics of city and province. 4,494 EDs are selected from the strata as the sample Eds. Enumerators interview about 100,000 livestock households in the sample EDs.

All households breeding livestock over the appointed scale are enumerated whether they are in the sample EDs or not. We call it as take-all survey. The results are summed up together with estimated sample survey.

<Table 1> Summary of the difference between the previous and new sample design for livestock statistics surveys

	Previous sample design	New Sample design
Population	1995 National Agriculture Census	2000 National Agriculture Census
Sampling frame	Population and Housing Census	Population and Housing Census
Stratum index	Number of head of breeding livestock	Number of head of breeding livestock
Strata size by city and province	3 ~ 20 plus one purposive stratum	2 ~ 18
Sampling survey unit	4,767	4,494
Sample properties	Rotation sample (rotation 20% every year)	Fixed sample
Kind of breeding livestock	Korean-beef cattle, dairy cows, pigs, chickens (4 kinds)	Korean cattle, beef cattle, dairy cows, pigs, chickens (5 kinds)

3. Population Analysis

1) Change of the number of livestock production household

Based on the National Agriculture Survey of 1995 and 2000, the status of breeding

livestock is changed a lot. In particular, the number of livestock production household with three kinds of livestock such as Korean-beef cattle, dairy cows, pigs, excluding chickens, decreases very quickly. From the population analysis, the number of livestock production household with Korean-beef cattle and pigs fall off by a half.

<Table 2> Changes in the number of livestock production household

City & Province	Korean-beef cattle		Dairy cows		Pigs		Chickens	
	1995	2000	1995	2000	1995	2000	1995	2000
Seoul	30	19	14	5	27	15	56	53
Busan	980	402	183	45	229	133	449	597
Daegu	3,522	1,660	296	144	219	130	1,021	983
Inchon	2,236	785	394	191	1,625	476	2,489	1,986
Gwangju	1,292	494	121	52	112	53	503	843
Daejun	1,551	639	56	16	49	34	620	486
Uoolsan	5,487	3,476	92	50	182	123	537	1,155
Kyounggi	24,686	9,815	9,249	5,114	5,343	2,648	9,266	14,188
Kwangwon	38,132	19,496	1,040	894	1,061	963	12,714	13,884
Chungbuk	38,645	18,184	1,328	1,042	1,083	761	6,934	9,227
Chungnam	68,093	32,683	3,539	2,310	12,022	4,276	11,208	15,538
Joebuk	41,805	20,873	1,369	993	5,830	3,561	8,665	12,228
Joennam	99,035	49,164	1,472	1,295	8,832	5,178	15,936	25,357
Kyoungbuk	99,577	48,792	1,718	1,621	3,298	2,052	17,734	23,287
Kyoungnam	86,568	49,289	1,536	1,163	6,233	3,329	12,806	16,588
Jeju	3,299	879	120	147	370	331	233	490
Total	514,938	256,650	22,527	15,082	46,515	24,126	101,171	136,940

2) Changes in the total number of heads of livestock production

The total number of heads of Korean-beef cattle falls off by a half, but the total number of other livestock has not changed or has increased little. By city and province, as with the case of Jeju Island, the total number of heads of dairy cows, pigs and chickens has increased.

<Table 3> Changes in the total number of heads of livestock production

City & Province	Korean-beef cattle		Dairy cows		Pigs		Chickens	
	1995	2000	1995	2000	1995	2000	1995	2000
Seoul	557	502	374	175	2,290	12,591	541,212	171,745
Busan	3724	2035	3437	1218	30260	36518	259660	166264
Daegu	25554	14611	6481	5890	38725	39612	425686	414766
Inchon	21082	12271	9231	6141	111915	69522	966709	1450702
Gwangju	7059	3305	1749	1401	14763	6337	306520	349565
Daejun	5814	4136	1203	471	8283	3704	184053	301385
Uoolsan	32448	20204	2160	2020	32156	39129	498317	430230

Kyonggi	223970	139082	206939	191406	1542126	1587753	27752614	31045784
Kwangwon	172979	97604	23025	25722	227889	286849	4027384	5153975
Chungbuk	168051	104921	28301	30647	268817	392605	5142424	10107869
Chungnam	377334	196734	77082	85546	1093070	1249443	12283110	19828744
Joebuk	204249	134480	36682	39107	525196	752978	11001695	15710530
Joennam	441722	227839	34809	37518	511797	666208	7736577	15556000
Kyoubuk	504469	276410	42934	49036	691667	868279	12803624	14967161
Kyounam	336114	206719	38911	36836	722739	749853	6733321	7735856
Jeju	29185	16742	3920	5147	203118	315928	923788	1252209
Total	2554311	1457586	517238	518284	6006811	7059309	91099694	124642785

3) Changes in the average head of livestock per household

From <Table 4>, the average number of all kinds of livestock per household increases and then the number of livestock per household become large. Particularly, in the case of pigs, the average number is increased more than twice.

<Table 4> Changes in the average of head of livestock per household

City & Province	Korean-beef cattle		Dairy cows		Pigs		Chickens	
	1995	2000	1995	2000	1995	2000	1995	2000
Seoul	18.57	26.42	26.71	35.00	84.81	839.40	968.07	3,240.47
Busan	3.80	5.06	18.78	27.07	132.14	274.57	578.31	278.50
Daegu	7.26	8.80	21.90	40.90	176.83	304.71	416.93	421.94
Inchon	9.43	15.63	23.43	32.15	68.87	146.05	388.39	730.46
Gwangju	5.46	6.69	14.45	26.94	131.81	119.57	609.38	414.67
Daejun	3.75	6.47	21.48	29.44	196.04	108.94	296.86	620.13
Uolsan	5.91	5.81	23.48	40.40	176.68	318.12	927.96	372.49
Kyonggi	9.07	14.17	22.37	37.43	285.26	559.60	2995.10	2,188.17
Kwangwon	4.54	5.01	22.14	28.77	214.79	279.18	316.77	371.22
Chungbuk	4.35	5.77	21.31	29.41	248.22	515.91	741.62	1,089.56
Chungnam	5.54	6.02	21.78	37.03	90.92	292.20	1,095.92	1,276.15
Joebuk	4.89	6.44	26.79	39.38	90.09	211.45	1,269.67	1,284.80
Joennam	4.46	4.63	23.65	28.97	57.95	128.66	485.48	613.48
Kyoubuk	5.07	5.67	24.99	30.25	209.72	423.14	721.98	642.73
Kyounam	3.88	4.19	25.33	31.67	115.95	221.07	525.79	466.35
Jeju	8.85	19.05	32.67	35.01	548.97	954.47	3964.76	2,555.53
Average	4.96	5.68	22.96	34.36	129.14	292.60	900.45	910.20

4) Number of survey units

On the basis of the household with more than one head of breeding cattle, the survey unit decreases to 2,175 from that of 1995. This represents a decrease in the number of household breeding cattle, but the heads of breeding cattle by survey unit are slightly increased.

<Table 5> Number of survey units

City & Province	Household breeding cattle survey unit		
	1995	2000	Change
Seoul	68	68	0
Busan	335	298	-37
Daegu	502	508	+6
Inchon	585	490	-95
Gwangju	325	333	+8
Daejun	313	262	-51
Uoolsan	488	513	+25
Kyonggi	5,559	5,762	+203
Kwangwon	3,004	2,919	-85
Chungbuk	2,916	2,693	-223
Chungnam	5,179	4,874	-305
Joebuk	3,996	3,681	-315
Joennam	6,407	5,928	-479
Kyongbuk	7,040	6,567	-473
Kyongnam	5,427	5,186	-241
Jeju	772	659	-113
Total	42,916	40,741	-2,175

4. New Sample Design

The new sample design is based on the "2000 National Agriculture Survey". This sample design is almost the same as before.

1) Objective of Survey

The survey is to find out number of households and number of head of livestock to provide the basic data for making the national livestock policy. It surveys to five kinds of main livestock such as Korean cattle, beef cattle, dairy cows, pigs and chickens.

2) Periodicity, Reference date, Enumeration period

Periodicity : Four times (March, June, September, and December) a year.

Reference date : March 1, 2003(for the Livestock Statistics Survey of March 2003).

Enumeration period : 1 - 15 of March, 2003 (15 days).

3) Sampling Design

Population : 40,741 survey units which include breeding cattle household in the 2000 Population and Housing Census sampling frame.

Use take-all survey and sample survey together

Sample : 4,494 survey units.

Error limit : national 2%, province 3%, Seoul and 6 big cities 5%.

4) Take-all survey

In a previous sample design, all households breeding livestock about 10,000 over the appointed scale of 20 heads for beef cattle, 20 for dairy cow, 100 for pigs and 2000 for chickens are investigated. This includes enterprises, communities and public institutions.

In a new sample design, new criteria are applied to attain the minimum non-response errors and sampling errors. Based on the new criteria for take-all survey, the minimum number of head of each livestock by city and province are the following:

<Table 6> Criteria for take-all survey

City and Province	Korean-beef cattle			Dairy cows		Pigs		Chickens	
	Previous	New Korean cattle	New Beef cattle	Previous	New	Previous	New	Previous	New
Seoul	30	20	20	30	30	100	500	3,000	10,000
Busan	20	20	20	25	20	300	400	2,500	5,000
Daegu	40	50	30	40	50	250	400	2,000	10,000
Inchon	50	60	30	50	40	500	700	6,000	18,000
Gwangju	30	20	20	25	20	300	300	4,000	10,000
Daejun	35	30	40	25	20	200	200	6,000	10,000
Uoolsan	50	50	20	25	40	300	700	4,000	6,000
Kyonggi	60	80	80	60	70	800	1,200	25,000	35,000
Kwangwon	100	70	30	25	35	500	700	12,000	20,000
Chungbuk	150	90	120	50	40	500	900	10,000	20,000
Chungnam	300	300	80	55	55	800	1,000	10,000	30,000
Joebuk	200	120	50	45	40	300	600	21,000	18,000
Joennam	300	400	50	40	45	550	500	20,000	35,000
Kyoubuk	200	300	60	40	45	850	1,100	8,000	11,000
Kyounam	130	180	40	40	45	650	800	8,000	18,000
Jeju	150	40	30	20	40	1,100	1,000	5,500	10,000

The number of household and the head of livestock for take-all survey are the following:

<Table 7> The number of household and the number of heads for take-all survey by city and province (based on 2000 Agricultural Census)

City/ Province	Korean cattle		Beef cattle		Dairy cows		Pigs		Chickens	
	House holds	Heads	House holds	Heads	House holds	Heads	House holds	Heads	House holds	Heads
Seoul	9	436	12	444	4	165	3	12,000	5	170,000
Busan	21	880	0	0	30	1,070	38	30,560	10	133,500
Daegu	68	4,665	10	439	43	3,598	25	29,500	12	330,000
Inchon	31	3,159	26	3,234	67	3,668	33	36,080	25	1,197,500
Gwangju	46	1,544	5	198	25	1,187	5	5,050	14	321,000
Daejun	40	2,134	1	50	7	428	6	2,700	8	263,000
Uolsan	38	2,642	6	253	26	1,685	21	27,170	13	368,000
Kyounggi	184	22,934	118	18,940	496	44,158	358	837,673	269	16,479,110
Kwangwon	104	10,371	39	2,074	306	18,518	134	197,506	98	4,141,500
Chungbuk	70	9,054	54	13,033	351	20,758	135	274,142	220	8,650,100
Chungnam	8	4,720	37	11,511	436	36,189	438	782,131	297	13,425,500
Joebuk	71	12,360	55	6,217	480	30,962	414	548,344	329	13,342,364
Joennam	4	2,260	62	6,885	355	25,143	457	536,812	189	11,578,300
Kyoungbuk	10	4,087	67	7,910	453	30,085	207	490,990	398	12,146,940
Kyoungnam	24	5,560	27	3,362	359	24,603	336	521,043	146	6,060,500
Jeju	91	7,211	57	3,396	62	4,111	114	223,280	32	1,003,000
Total	819	94,017	576	77,946	3,500	246,328	2,724	4,554,981	2,065	89,610,314

5) Sample survey

In a previous sample design, all households which have less than the "Take-all survey" criteria is considered as sample. If the household in a sample unit have more number of heads than the specified size, then consider the sample unit as a purposive sample and investigate all household in the sample unit. If the households in a sample unit have less than the specified size, then stratify the sample unit into several strata by the number of livestock and select simple random sample household from each stratum. Stratification is made by the maximum number of breeding ratio of livestock in sample unit. The maximum number of strata is 20. Therefore the maximum number of strata was 21 with Purposive stratum.

In a new sample design, one big change relative to the previous design is survey to the five main livestock instead of four livestock, i.e., the "Korean-beef cattle" is separated into "Korean cattle" and "Beef cattle".

Stratification for new design is made by the maximum number of breeding ratio (number of heads in a sample unit divided by the total (including total number from take-all survey) number of head by livestock) of livestock in sample unit. The criteria is based on the number of heads by livestock instead of city or province. To make it insensitive to the variations of the

number of heads by the time, we make the minimum number of sample by stratum is 4, and the number of strata in city area is less than 10, and province is less than 15. In the new sample design, the purposive stratum is not considered. Same to the previous sample design, we first calculate the sample size by stratum for livestock to obtain the target CV using Neyman allocation, and use the maximum value for the sample size of the stratum.

Stratification: Considering the number of head of breeding cattle, stratify the survey unit into 2-18 strata based on the size of livestock breeding. Then select 4,494 survey units. The total number of stratum of the new sample design is less compared to the previous sample design.

Sample size

$$n = \frac{(\sum W_h S_h)^2}{V' + (1/N)(\sum W_h S_h)^2}$$

where n : number of survey units

N : number of population units

W_h : N_h / N

S_h : sample standard deviation.

V' : target variance

5. Estimation for New Sample Design

1) Estimation for city total (city and Province)

Total

$$\hat{Y}_s = \sum_{h=1}^L N_h \left(\frac{1}{n_h} \sum_{i=1}^{n_h} y_{hi} \right) + \text{take-all stratum total}$$

Variance of total

$$V(\hat{Y}_s) = \sum_{h=1}^L N_h^2 \left(1 - \frac{n_h}{N_h} \right) \frac{S_h^2}{n_h}$$

Coefficient of variance

$$CV(\hat{Y}_s) = \frac{V(\hat{Y}_s)^{1/2}}{\hat{Y}_s}$$

2) Estimation of national level

Total = sum of the total estimates of all cities and provinces

Variance = sum of the variance estimates of all cities and provinces

Coefficient of variation = $(\text{national level variance})^{1/2}/(\text{national level total})$

(Note) In some city area, we may have 0 for the estimate of the number of head to a livestock. In this case, we use 0 for the variance and coefficient of variance.

6. Maintenance and Replacement of Sample

1) The management of take-all survey

The livestock statistics survey is composed of the take-all survey and sample survey. A sample survey is useful to provide information that is lacking in the take-all survey. Because the surveyed households in take-all survey may change with every survey time, it is very difficult to maintain the survey unit in the take-all compared with the sample parts. It is desirable to carry out the survey for the take-all survey before the sample survey because then the problems can be adjusted for the take-all survey from the sample survey.

If the sample survey is taken before the take-all part of the survey, then the households in the sample survey units can be managed well; as a result of this, the estimation error is smaller than the actual one and the estimator for the breeding cattle state (number of heads of breeding cattle, number of breeding cattle household) can be underestimated.

If you find a household that must be in the take-all survey, but appears as a sample survey unit, the households are not added to the take-all survey but added to the sample survey. If you do this way, of course, the CV increase, but it is acceptable to represent take-all survey errors. However, we can not be sure that the sample survey is managed better than the take-all survey in the survey every time.

To avoid the effect of the sample design, if possible, the criteria of the take-all survey must be very strict.

2) The management of the sample survey unit

The sample survey unit includes the fixed household every time, but the breeding livestock state of that household will change. The sample survey unit represents the changing of the number of heads of breeding livestock in the othersurvey unit in the same stratum. Although a drastic change occurs in the number of heads of breeding livestock in the sample survey unit,

it refers to the variation of the breeding livestock state. It is not recommended changing stratum boundaries to downsize the variation. If a sample survey unit is moved to other stratum, the estimate would not be correct and also the estimation error would be under-estimated.

3) Sample replacement

Sample replacement, in principle, must be avoided. If actual errors are greater than the theoretical errors, a sample survey based on theoretical theory is meaningless. So if the sample district is impossible to survey or includes major errors, sometimes it is better to exchange the district with another district to reduce the total errors.

In Korea, remote places, deserted islands, and the northern DMZ neighborhood survey units can not be surveyed so we prepared about 20% extra samples. Especially there are many breeding cattle households in the DMZ neighborhood that are more difficult to survey than other areas, so it is necessary to prepare the spare samples.

7. Considerations of Livestock Survey

1) Sampling design for household holding heads of livestock change

Until now, many countries have revised the sample design for livestock survey every 5-10 years based on the agricultural census. It is not effective and is time-consuming. In the future, the sample design must focus on maintaining the efficiency for changing population. To achieve this goal, the boundaries of the take-all survey should be upward and we suggest that the take-all survey must be conducted before the sample survey. In addition, we can consider that the number of strata is decreasing.

2) The efficient sample design

The "Livestock Statistics Survey" has been improved with sample designs several times. In the latest version, we can find the optimal number of strata with smallest sampling errors through the computer simulation study due to developments in computer software that were impossible in the past. Thus we can consider the development of a simulation algorithm to find the optimal sample size or number of strata, and so on. Also, we must consider the weighting adjustment to overcome discrepancies in survey times.

3) Data sources and livestock category

In the "2000 Agricultural Census", we only collected data for four main types of livestock

: Korean-beef cattle, dairy cow, pigs, and chickens. In the sample design for the "2003 Livestock Statistics Survey", we classified the livestock into five categories: Korean cattle, beef cattle, dairy cow, pigs, and chickens. Because of the lack of the data, we used "Special Beef Cattle Survey" which is conducted by the Ministry of Agriculture and Forestry after the "2002 Agricultural Census". Using this survey results, we made the estimates, and used that for the new sample design.

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