Determining Dairy Delivery Case Life Using a Practical Sampling Procedure
ABSTRACT

Loss of dairy delivery cases continues to plague Florida dairy processors despite control measures adopted by many firms in recent years. Losses to Florida processors in 1981 may exceed $2,000,000.

This study provides managers of dairy processing firms with a management tool which will help to (1) determine the rate of loss for different types of cases and (2) determine loss rates by age of case.

Key words: dairy delivery cases, dairy processing, dairy delivery case loss rates
Determining Dairy Delivery Case Life Using a Practical Sampling Procedure

Robert L. Degner and J. Scott Shonkwiler

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The Florida Agricultural Market Research Center
a part of
The Food and Resource Economics Department
Institute of Food and Agricultural Sciences
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The Florida Agricultural Market Research Center

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ACKNOWLEDGEMENTS

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Our appreciation is expressed to executives and employees of Borden, Inc., Orlando and Tallahassee, T. G. Lee Foods, Orlando, and Pet, Inc., St. Petersburg, for their excellent cooperation in providing data and access to their plants for developing and testing the case sampling procedure.

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SUMMARY

* Loss of dairy delivery cases continues to plague Florida dairy processors despite control measures adopted by many firms in recent years. Losses to Florida processors in 1981 may exceed $2,000,000.

* This study provides managers of dairy processing firms with a management tool which will help to (1) determine the rate of loss for different types of cases and (2) determine loss rates by age of case.

* A statistical sampling technique and analytical method has been developed which is simple and inexpensive to administer.

* The technique requires that each batch of cases be uniquely identifiable; the most practical way of doing this is to have the manufacturer imprint each lot of cases with a manufacture date.

* The dates of service for each batch of cases must also be ascertainable from company records.

* Large, legible manufacture dates facilitate the sampling procedure. The "easiest to read" dates can be sampled at the rate of 1,400-1,500 per hour compared with only 200-300 per hour for difficult to read date codes.

* The recommended sample size is 2,000 cases.

* Sampling may be done at any time after the most recent batch of cases has been thoroughly distributed throughout the system, usually about one month after introduction.

* Sampling may be done at any convenient location in the case storage area or on-line. If done on-line, an acceptable procedure would be to select every "nth" case as it passes by.

* Avoid bias in drawing the sample. Take care to include every case selected, regardless of type or legibility of date. Every effort must be made to determine dates of all cases selected.

* Tabulate the number of cases observed for each manufacture date. Then determine the proportion of each date to the original number purchased and placed into service. This proportion or ratio is the "sample ratio".
* The sample ratio for the most recent batch of cases in the system serves as a base. If it is assumed that none of the newest cases is missing, the sample ratio for the most recent batch is one, or equivalent to 100 percent (the percent of cases still in the system). The sample ratios for the other case dates expressed as a ratio to the sample ratio base reflects the proportion of each date left in the system.

* Comparison of results for different company locations, case types, or management practices can help identify ways to reduce case costs.
Determining Dairy Delivery Case Life Using a Sampling Procedure

Robert L. Degner and J. Scott Shonkwiler

Studies conducted by the Florida Agricultural Market Research Center (FAMRC) in 1977 and 1979 placed dairy delivery case losses for Florida dairy processors during 1976 and 1978 at $1.3 and $1.5 million, respectively (Mathis and Degner, 1977, 1979). Case losses cost processors 0.53 and 0.56 cents per gallon of fluid product for the respective study years.

Although most Florida dairy processing firms have adopted measures to ameliorate the case loss problem, many plant managers feel that losses are greater than ever. If the 1978 costs are simply adjusted for inflation, the current annual losses exceed $2 million. This continuing problem and the associated escalating costs make it imperative that processing plant managers be able to accurately monitor their case inventories and estimate the rate at which cases disappear from their distribution systems. Knowing the disappearance rate for cases of different materials or design, different case management policies, or for individual plants, would provide a management tool which could reduce future case losses. Further, accurate information on loss rates may be used to modify depreciation schedules, possibly resulting in tax savings.
OBJECTIVES

The primary objective of this study was to develop a technique for determining the rate of loss of dairy delivery cases for individual firms. Specific objectives were to:

1. Determine the relative loss rates for cases made of wire and plastic.
2. Determine case loss rates by age of case.
3. Provide processors with a sampling method to meet the above objectives which is relatively simple and inexpensive to administer.

RESEARCH PROCEDURE

The theoretical basis for the study rests on the ability to compare an observed (sample) distribution of dairy cases remaining in a system with a known distribution (over time) of case acquisitions. This comparison requires 1) the ability to determine the actual numbers of dairy delivery cases placed in service by a given processing plant at specific points in time (from processing plant records) and 2) the ability to identify individual cases as to the date placed into service (from manufacture dates or codes stamped on cases).

Four major processing plants cooperated in the study. All provided case purchase records for a minimum of two years and all allowed access to case handling areas so that researchers could observe case flow rates and record case manufacture dates from a sample of cases. All plants were visited by FAMRC personnel one or more times in early 1981.
Unfortunately, none of the cooperating plants maintained the numbers of cases of a given manufacture date put into service on specific dates. Several plants had also received shipments of cases which had no manufacture date, thereby precluding the use of their case data. However, it was possible to examine records of case purchases and relate these to manufacture dates found on cases in several plants so as to obtain sufficient data to develop the basic procedure. Further, information on time requirements and other practical aspects of sampling was obtained at all cooperating plants. Several techniques were developed and evaluated, but the one described in the following section was judged to be the simplest and most practical to use, and yet very effective.

**Determining Case Life Through Sampling**

In order to use the case sampling procedure described below, a processing plant must have 1) cases which have manufacture dates or codes imprinted on them and 2) accurate records which indicate when cases of a particular manufacture date were put into service.

The case manufacture date or code is extremely important because it uniquely identifies a given batch of cases. Most case manufacturers routinely imprint or emboss numbers representing the month and year on their cases. On plastic cases the numerals are usually found imprinted on two opposing side panels. On wire cases, they are usually stamped or embossed on several of the sheet metal corner supports.

Some cases, particularly those made of plastic, will have a date code rather than a numeric month and year date. Typically, such codes will consist of a grid or "clock" which will contain one dot for January, two for February, etc. The year of manufacture will usually be found in
the center of the grid or circle (Figure 1). On some cases the code is found on a side panel, and on others, the bottom. Obviously, the size and location of the manufacture date greatly affects legibility, which in turn affects the time required to record dates from a sample of cases. Plastic cases with relatively large (1/8 inch to 1 inch) numerals in contrasting colors on side panels could be sampled at the rate of 1,400 to 1,500 per hour. Metal cases with numerals about the same size were sampled at 400 to 500 per hour, and only 200 to 300 plastic cases with date codes could be sampled per hour (Table 1).

Table 1.--Sampling rates for various types of cases or types of dates.

<table>
<thead>
<tr>
<th>Type of case, date</th>
<th>Sampling rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic, large contrasting numerals</td>
<td>1400 - 1500 (Cases per hour)</td>
</tr>
<tr>
<td>Metal, large embossed numerals</td>
<td>400 - 500</td>
</tr>
<tr>
<td>Plastic, coded dates</td>
<td>200 - 300</td>
</tr>
</tbody>
</table>

Obviously, the sampling rate depends on the skill and experience of the sampler, the location in the plant where sampling is done, and the method used to record the data. FAMRC researchers found that dictating dates into a portable tape recorder saved considerable time compared with writing them down. If it is anticipated that the dates will be used for sampling purposes, every effort should be made to get the manufacturer to put large numeric dates on the side panels or the corner supports. Codes should be avoided, as they require considerable more time to decipher and record.
Figure 1. Typical date codes found on dairy delivery cases. Both indicate a case manufactured in March of 1981.
Most plants visited had an assortment of different case types, with different types of dates or codes. When sampling from such an assortment, it is important to read every date on cases included in the sample, not just those that are most legible. This will reduce sample bias, which is discussed in greater detail in the next section. If the above conditions have been met, i.e., dated cases and accurate records indicating when cases of a particular manufacture date were put into service, this procedure can be used. The next step is to record manufacture dates from a random sample of cases.

Obtaining the Sample

The optimum time for sampling cases is as soon as possible after the most recent batch of cases has been absorbed by the system and has become randomly distributed. While the exact time is difficult to specify, it is estimated to be about one month after introduction of new cases to the system for most plants. If sampling is done too soon, the majority of the newest cases might remain together, and could be undersampled if they are all at customers or away from the plant at once. Similarly, they could be oversampled if large numbers are back at the plant simultaneously. On the other hand, if too much time elapses after introduction of a batch of cases into the system, substantial numbers could already have been lost and estimates of case losses based on the technique described in the next section may be too low.

A sample of approximately 2,000 cases is sufficient for most plants to insure reasonable accuracy. Every effort must be made to insure that a random sample of dates will be recorded. In most plants, cases of all ages and types will be uniformly or randomly distributed throughout the distribution system. However, if cases tend to be sorted for some
reason, i.e., because of driver preference for a particular type of case or because some cases pose handling problems in certain lines, care must be exercised or a biased sample may result.

At the four cooperating plants, samples were obtained in various locations such as filling lines, case storage areas, unloading docks, and the case washing line. The sample dates should be obtained wherever dates can be easily read, without introducing bias into the sampling procedure.

Bias can be introduced whenever the sampler cannot read the date on every case that passes by or if he cannot keep up when sampling every "nth" (every 3rd, 4th, etc.) case that passes by when sampling in a line. Bias would be introduced because the sampler would tend to read highly legible cases, but undersample cases with less legible dates. Similarly, bias can be introduced in sampling from stacked cases if the sampler is less than diligent about recording dates that are difficult to read.

FAMRC researchers found that the line emerging from the case washer was the best place to obtain a sample in most plants. As the cases emerge from the washer, they are usually stacked five or six cases high. A sampler can easily record dates from every case in a given stack. If more time is required to examine a hard to read date, the case can be removed from the line for closer inspection and another substituted. Similarly, a whole stack maybe removed from the line for closer scrutiny. Any number of stacks of cases can be ignored, but every case in a given stack must be read to minimize bias.
The only type of case that should be ignored is a foreign case. Foreign cases constituted an extremely small proportion of the cases observed in cooperating firms' plants, but even so, foreign cases cannot be analyzed because of the obvious lack of acquisition data.

Analyzing the Sample: An Example

The case data shown in Table 2 is based on actual case acquisition records and a sample of case manufacture dates observed at one of the cooperating plants. The actual numbers of cases purchased have been scaled (adjusted by a constant value) to maintain confidentiality, however. Data in columns (1), (2), and (3) were obtained from plant records.

The plant was visited in early February and case manufacture dates were recorded from a sample of 2,173 cases. Early February was chosen as the time to draw a sample because the plant had acquired a shipment of cases in early January; about a month had elapsed since the last batch of cases had been acquired. A month was judged to be sufficient to allow the newest cases to be thoroughly dispersed in the system.

Fortunately, case manufacture dates corresponded very closely with the dates when cases were put into service. The numbers of cases observed of each manufacture date were tabulated; the results are shown in column (4) of Table 2. For example, in our sample of 2,173 cases, 145 were observed out of the shipment acquired with the date 1-81. Because tabulation only requires counting, it is easily done by hand, but clerical time can be saved by using a small computer if available.

After tabulating column (4), column (5) is calculated by dividing the number of cases observed of a specific age by the number of cases
Table 2.--An example of data and calculations required to determine case life.

<table>
<thead>
<tr>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case manufacture/</td>
<td>Months in system</td>
<td>Number of cases purchased</td>
<td>Number of cases in sample</td>
<td>Sample ratio</td>
<td>Cases remaining</td>
<td>Cases remaining number</td>
</tr>
<tr>
<td>acquisition date</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-81</td>
<td>1</td>
<td>787</td>
<td>145</td>
<td>.1842</td>
<td>1</td>
<td>787</td>
</tr>
<tr>
<td>9-80</td>
<td>5</td>
<td>3,637</td>
<td>532</td>
<td>.1463</td>
<td>.794</td>
<td>2,888</td>
</tr>
<tr>
<td>2-80</td>
<td>12</td>
<td>2,132</td>
<td>221</td>
<td>.1057</td>
<td>.563</td>
<td>1,200</td>
</tr>
<tr>
<td>9-79</td>
<td>17</td>
<td>4,929</td>
<td>401</td>
<td>.0814</td>
<td>.442</td>
<td>2,179</td>
</tr>
<tr>
<td>5-79</td>
<td>21</td>
<td>5,197</td>
<td>353</td>
<td>.0679</td>
<td>.369</td>
<td>1,918</td>
</tr>
<tr>
<td>10-78</td>
<td>27</td>
<td>3,939</td>
<td>243</td>
<td>.0617</td>
<td>.325</td>
<td>1,320</td>
</tr>
<tr>
<td>5-78</td>
<td>33</td>
<td>3,443</td>
<td>140</td>
<td>.0467</td>
<td>.221</td>
<td>761</td>
</tr>
<tr>
<td>12-78</td>
<td>38</td>
<td>2,644</td>
<td>138</td>
<td>.0522</td>
<td>.263</td>
<td>748</td>
</tr>
<tr>
<td>Totals</td>
<td>--</td>
<td>26,708</td>
<td>2,173</td>
<td>-----</td>
<td>----</td>
<td>11,801</td>
</tr>
</tbody>
</table>

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a Case manufacture dates are shown here; ideally they should correspond to acquisition dates. If they do not, column (2) should be adjusted to reflect as nearly as possible the date cases were actually put into service, rounded to the nearest month.

b Column (5) is calculated by dividing the number of cases observed of a specific age by the number of cases bought of the same age. For example, 145/787 = .1842, etc.

c Column (6) is calculated by dividing every number in column (5) by the first number in column (5). For example, .1842/.1842 = 1, .1463/.1842 = .794, etc. The resulting numbers represent the proportions of cases of each batch that remain in the system. For percentages, multiply proportions by 100.

d Column (7) is calculated by multiplying the proportion of cases remaining in the system by the number of cases originally purchased, i.e., columns (3) and (6).
bought or acquired of the same age. For example $145 \div 787 = 0.1842$, 
$532 \div 3,637 = 0.1463$, etc. The resulting numbers are termed the "sample ratio" (Table 2). The sample ratios are then used to calculate column (6), the proportion of cases of specific ages remaining in the system. This technique has been used by another researcher to analyze similar problems (Hausman, 1979).

The values in column (6) are calculated by dividing every number in column (5) by the first number in column (5) for example, $0.1842 \div 0.1842 = 1$, $0.1463 \div 0.1842 = 0.794$, etc. This calculation implicitly assumes that none of the latest batch of cases is missing. The sample ratios for all other batches of cases are expressed relative to the most recent batch. The values calculated for column (6) represent the proportions of cases remaining of each batch. For example, about 79 percent of the cases are estimated to be in the system at the end of five months (those acquired 9-80), but only 33.5 percent of those purchased 27 months previously i.e., 10-78 (Table 2). Obviously, to calculate the proportion of cases missing, one would subtract the proportion remaining from 1.0. The proportions are converted to percentages by multiplying by 100.

After the proportions of cases remaining in the system have been estimated (column 6), estimates of actual case numbers of each age group can be calculated by multiplying the values in column 6 by the numbers of cases originally purchased (Column 3). These estimates are shown in column (7). Summing the remaining cases of all ages yields an estimate of total inventory. In Table 2, an estimated 11,801 cases remain of the 26,708 purchased in the last 38 months.

The values in column (6) can also be plotted to give a visual or graphic representation of case losses over time (Figure 2). If an
Figure 2. Percent of cases remaining in a distribution system over time (from Table 2, Column 6).
estimate of the percentage of cases remaining is desired for a point in
time between actual observations, a smooth, free hand curve can be drawn
through (among) the points, which attempts to minimize the deviations of
individual points (Figure 2). The approximate proportion of cases
remaining in the system can then be read off the graph for any time
period. If the values from column (6) are highly variable, it may be
difficult to draw an accurate, free hand curve through the resulting
plotted points. In such cases, the mathematical relationship between
the proportions of cases remaining (or lost) and time can be easily and
accurately estimated using a statistical procedure discussed in the
Appendix.

CONCLUSIONS

Data limitations precluded the determination of relative loss rates
for cases made of different materials or designs. However, the sampling
technique developed provides dairy processing plant managers with a
technique which can be used within their respective firms to estimate
case life for their own unique operations. It is important that managers
begin to have each new shipment of cases uniquely identified with legible
manufacture dates. They should also record the dates that cases are
actually put into service. This will allow case life to be monitored
using this procedure. An analysis of case life for different company
locations, case types, and management practices can help identify ways
to reduce case costs.
APPENDIX
APPENDIX

Case loss can be expressed as a mathematical function of the form
\[ Y = e^{bt} \]
where:
\[ Y = \text{the ratio of remaining cases, i.e., column (6) from Table 2, also shown in Appendix Table 1.} \]
\[ e = \text{logarithmic base, 2.7182818, a constant.} \]
\[ t = \text{time (in months) that various batches of cases have been in the system, i.e., column (2) Table 1, also shown in Appendix Table 1. Other time units such as days or years could be used if desired.} \]

The objective of this procedure is to estimate the value of the parameter "b" in the above equation by using a simplified form of regression analysis. The purpose of this mathematical approach is to be able to calculate an "average" relationship between case loss and time, resulting in a smooth, accurate curve such as the one shown in Appendix Figure 1. This is especially useful when the calculated points (column 6) are highly variable. Points on the curve were calculated by allowing "t" to take on values from 1 to 38 after "b" was estimated. To estimate "b", the following steps are required:

1. Calculate columns (2) and (6) of Table 1, shown again in Appendix Table 1.
2. Construct column (8) of Appendix Table 1 by taking the natural log (base e) of column (6). Many inexpensive hand held calculators will perform this operation.
3. Add the squares of the entries in column (2):
\[ 1^2 + 5^2 + 12^2 + 17^2 + 21^2 + 27^2 + 33^3 + 38^2 = 4162 \]

4. Add the products of the entries in column (2) times the entries in column (0):
\[ (1)0 + 5(-.231) + 12(-.574) + 17(-.816) + 21(-.997) + 27(-1.093) + 33(-1.509) + 38(-1.262) = -170.1 \]

5. The parameter \( b \) equals the result in step 4 divided by the result in step 3:
\[ -170.1 \div 4162 = -.04087 \]

6. The equation is \( y = e^{-0.04087t} \).

7. Cases remaining can now be estimated for any time period between one and 38 months. For example, the estimated proportion of cases remaining after 24 months in the system would be calculated as follows:
\[ Y = 2.7182818^{-0.04087(24)} \]
\[ Y = 2.7182818^{-0.98088} \]
\[ Y = .375 \text{ or } 37.5 \text{ percent} \]

8. The time required for a firm to lose a given proportion of cases can also be calculated. The formula below will allow you to solve for \( t \) given \( Y \):
\[ t = \frac{\ln Y}{b} \]

For example, to calculate the number of months it would take for half the cases to leave the system, take the natural log of .50, divide the resulting logarithm by -.04087, the estimated \( b \) value discussed above.
\[ t = -0.693147 \div -0.04087 = 16.96 \text{ months} \]
Appendix Table 1.--An example of data and calculations required to determine case life using a statistical procedure.  

<table>
<thead>
<tr>
<th>Column b</th>
<th>Column (6)</th>
<th>Column (8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Months in system</td>
<td>Cases remaining, proportion</td>
<td>Log of column (6)</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>.794</td>
<td>-.231</td>
</tr>
<tr>
<td>12</td>
<td>.563</td>
<td>-.574</td>
</tr>
<tr>
<td>17</td>
<td>.442</td>
<td>-.816</td>
</tr>
<tr>
<td>21</td>
<td>.369</td>
<td>-.997</td>
</tr>
<tr>
<td>27</td>
<td>.335</td>
<td>-1.093</td>
</tr>
<tr>
<td>33</td>
<td>.221</td>
<td>-1.509</td>
</tr>
<tr>
<td>38</td>
<td>.283</td>
<td>-1.262</td>
</tr>
</tbody>
</table>

a The statistical estimating procedure is regression analysis, used to estimate the parameter \( b \) of the function \( Y = e^{bt} \) where

\[ Y = \text{the ratio of remaining cases, column (6)} \]

\[ t = \text{time (months) that various batches of cases have been in the system, and} \]

\[ e = \text{logarithmic base, 2.7182818.} \]

b Columns (2) and (6) are taken from Table 2 in the text. The values in column (8) are natural logs (base e) of the values in column (6).
Appendix Figure 1. Percent of cases remaining in a distribution system over time.
REFERENCES

