



Economic analysis of cattle shrinkage
by Glen R Purnell

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree
of Master of Science in Agricultural Economics

Montana State University

© Copyright by Glen R Purnell (1953)

Abstract:

no abstract found in this volume

ECONOMIC ANALYSIS OF CATTLE
SHRINKAGE

by

GLEN R. PURNELL

A THESIS

Submitted to the Graduate Faculty

in

partial fulfillment of the requirements

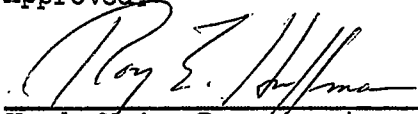
for the degree of

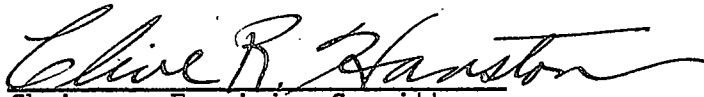
Master of Science in Agricultural Economics

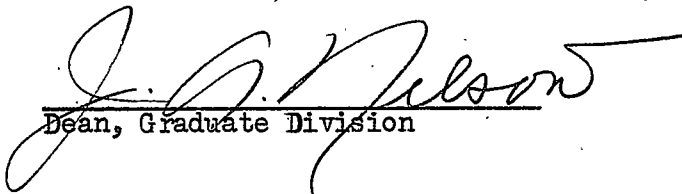
at

Montana State College

Approved:


Head, Major Department


Chairman, Examining Committee


Dean, Graduate Division

Bozeman, Montana
August, 1953

RECEIVED
MONTANA STATE COLLEGE
AUG 19 1953

N1378
p975e
cop. 2

CONTENTS

<u>Title</u>	<u>Page</u>
List of Tables	4
List of Figures	6
Acknowledgments	7
Abstract	8
PART I: INTRODUCTION	9
A. Selection of the Field of Investigation	9
B. The Problem	11
C. Hypotheses	18
D. Objectives of the Investigation	19
E. Boundaries and Limitations	19
F. Review of Literature	20
PART II: EMPIRICAL ANALYSIS	27
A. Methodology	27
B. Extent of Shrinkage	29
1. Calves	29
2. Cows	33
3. Steers and Heifers	36
C. Factors Causing Shrinkage	44
D. Functional Relationship Between Factors Causing Shrinkage and Extent of Shrinkage	47
PART III: ECONOMIC IMPLICATIONS OF SHRINKAGE OCCURRING DURING THE MARKETING PROCESS	53
A. Theoretical Framework for Appraisal of Economic Signifi- cance	53

<u>Title</u>	<u>Page</u>
1. Theoretical Assumptions	53
2. Economic Analysis of Empirical Evidence	59
B. Rational Marketing Behavior	76
1. Budget Analysis	76
PART IV: SUMMARY AND CONCLUSIONS	85
A. Summary of the Investigation	85
B. Extent to Which Hypotheses were Substantiated	87
C. Recommendations Based and Findings of this Study	89
D. Suggestions for Further Research	90
APPENDIX	92
Appendix A - Questionnaire	93
Appendix B - Supplementary Tables	97
BIBLIOGRAPHY	100

LIST OF TABLES

<u>Number</u>	<u>Title</u>	<u>Page</u>
I	Cash and Gross Farm Income Obtained from Meat Animals in the United States, 1950 and 1951.....	11
II	Cost of Transportation for Yearling Steers, Kilgore, Nebraska, to Montecello, Iowa. Basis Loading Weights, 1949	16
III	Shrinkage of Feeder Calves Shipped from Montana to Ohio.	31
IV	Shrinkage of Montana Calves, Determined by the Difference in Loading and Off-Car Weights, and Transported by Rail to Market	31
V	Shrinkage of Montana Calves, Determined by the Difference Between Loading and Sales Weight. Transported by Rail and by Truck	32
VI	Shrinkage of Dry Cows in Montana, based on the Difference Between Loading and Sales Weight	35
VII	Shrinkage of Montana Feeder Heifers and Steers, Based on the Difference Between Loading and Sales Weights	38
VIII	Shrinkage of Montana Slaughter Heifers and Slaughter Steers---Based on the Difference Between Loading and Off-Car Weights	40
IX	Shrinkage of Montana Feeder Steers, as a Percent of Loading Weight---Based on the Difference Between Loading and Off-Car Weights	41
X	Shrinkage of Various Classes of Cattle in Montana, Gross Off-Car Shrink Compared with Net Sales Shrink	43
XI	Percent Shrink for 60 Fat Cattle Between Each Check Weighing During a 200 Mile Truck Haul	45
XII	Shrinkage and Refill of Feeder Cattle in Montana	72
XIII	Sales Costs for Selling Calves through Various Auctions in Montana, 1953	98
XIV	Cost of Freight on Feeder Stock Shipped from Various Points in Montana to St. Paul, Minnesota, 1953	99

NumberTitlePage

XV Prices Required from Different Sales Channels, to
Net Equal Returns

84

LIST OF FIGURES:

<u>Number</u>	<u>Title</u>	<u>Page</u>
1	Scatter Diagram Showing the Percent Shrink of Dry Cows in Relation to the Number of Hours Between Arrival and Sales, Montana, 1953	34
2	A Firm Facing a Purely Competitive Demand Curve, Places Two Quantities on the Market	54
3	A Firm Facing a Perfectly Elastic Demand Curve Seeks an Optimum	56
4	A Firm Facing Monopolistic Market Conditions	57
5	A Typical Demand and Cost Function in Agriculture	58
6	Equilibrium Positions of a Firm Acting Rationally and Irrationally with Respect to Welfare Maximization	60
7	A Beef Producing Firm Facing a Perfectly Elastic Demand for Beef, Places Two Quantities on the Market at a Price of 20¢ per Pound	64
8	Price---Supply Relationship for an Individual Firm Placing Animals on the Market Under Three Shrink Conditions	65
9	Pounds of Beef Lost in one Time Period and Regained in Another	69
10	An Optimum Position is Sought by a Firm Where Marginal Cost Equals Marginal Revenue	73
11	Pounds of Beef Lost Through Shrinkage in Several Time Periods	75
12	Pounds of Beef Regained as Compared to the Cost of Regain	75

ACKNOWLEDGMENTS

The author wishes to express sincere appreciation for the aid and encouragement extended by all those contacted throughout the course of his post-graduate work.

There has indeed been an uplifting and encouraging environment surrounding the graduate training program in the Department of Agricultural Economics. The professors, secretaries and graduate colleagues have been very helpful and tolerant.

Special gratitude is due to Doctor C. R. Harston for his guidance and assistance throughout the course of this study.

Acknowledgment is given to C. B. Brotherton and N. A. Jacobsen for their timely criticisms and suggestions while serving on the thesis committee.

Members of the Branch Experiment Stations at Havre and Miles City, and also farmers and dealers contacted in relation to this study, assisted in giving of their time and information for research purposes.

PART I.

INTRODUCTION

A. Selection of the Field of Investigation

The importance of livestock marketing to consumers and agricultural producers is revealed by statistics indicating that one-fourth of the consumers food expenditures go for meat, and that approximately one-third of farmer's total cash farm income in the United States is obtained from the sale of livestock. 1/ Of the consumer's meat dollar about 60 to 64 cents goes back to the producer during periods of high prices and the remaining 35 to 40 cents goes to processors and marketing agencies. 2/

Of the 1,903,000,000 acres of the continental United States, approximately 1,042,000,000 acres were classified as pasture and grazing lands in 1930. 3/ In addition, a considerable part of the 359,000,000 acres of harvested crop land was devoted to the production of grain, hay, and other feeds for livestock. There were estimated 93,676,000 cattle and calves, 31,611,000 sheep and lambs, and 54,632,000 hogs on farms in the United States on January 1, 1953. The total farm value of this livestock as of that date was estimated to be \$13,916,595,000, of which cattle and calves accounted for \$11,997,173,000; hogs, \$1,416,365,000, and sheep and lambs,

1/ United States Department of Agriculture, Bureau of Agricultural Economics, Agricultural Statistics, 1952.

2/ United States Department of Agriculture, Bureau of Agricultural Economics, The Livestock and Meat Situation, January, 1950, p. 13.

3/ National Resources Board, Report of the Land Planning Committee, Washington, D. C., December, 1934, Part II, p. 109.

\$503,057,000. 1/

The gross farm income obtained from the meat animals---cattle, hogs, and sheep---in the United States amounted to \$11,818,045,000 in 1951, as shown in Table I. The gross farm income includes the cash income obtained from the sale of meat animals and meat and the estimated value of the meat consumed on the farm. The gross farm income obtained from cattle and calves was greater than that obtained from hogs; the income obtained from sheep and lambs was much less important. From the above information the importance of the livestock industry can readily be observed, and cattle occupy the outstanding position in this field.

The importance of the livestock industry in Montana is illustrated by the fact that approximately 52% of farm cash receipts are derived from livestock in this state. The state's production in 1952 in live weight was 624 million pounds of cattle and calves, 84 million pounds of sheep and lambs, and a little over 63 million pounds of hogs. 2/

Consumers are interested in obtaining meat at decreased costs and improved quality if possible in order that their food dollar will go farther and they can receive greater benefits through increased quality. Producers are ever anxious to trim the marketing share of the consumers food dollar to a minimum in order that the producers can get a maximum portion of this income for their own benefits.

1/ United States Department of Agriculture, Bureau of Agricultural Economics, Crop Reporting Board, Livestock and Poultry on Farms and Ranches, January 1, 1953.

2/ United States Department of Agriculture, Bureau of Agricultural Economics, Farm Production, Disposition and Income, Washington, D.C., April, 1953.

Table I. Cash and Gross Farm Income Obtained from Meat Animals in the United States, 1950 and 1951 (In thousands of dollars).

CLASS	CASH INCOME		HOME CONSUMPTION		GROSS INCOME	
	1950	1951	1950	1951	1950	1951
Cattle & Calves	\$5,677,344	\$6,937,145	\$95,225	\$117,870	\$5,772,569	\$7,055,015
Hogs	3,184,070	3,903,718	355,382	386,844	3,539,452	4,290,562
Sheep & Lambs	386,207	467,355	4,598	5,113	390,805	472,468
Total	9,247,621	11,308,218	455,205	509,827	9,702,826	11,818,045

Source: United States Department of Agriculture, Agricultural Statistics, 1952.

The importance of the livestock industry to the producer and consumer, as well as the particular importance of the cattle industry in Montana has led to the undertaking of the investigation as it is explained in the following sections.

B. The Problem

There is a large marketing cost in the livestock industry, which is partially due to the distance lying between the major production areas and the major consumption areas. Over forty percent of all beef cattle in the United States are located west of the 100th meridian. Thirty years ago two-thirds of the cattle shipped from the Western grazing areas each year were sold for immediate slaughter, and the remaining one-third were shipped

into the corn belt and other states to be fattened. 1/ At the present time probably a larger proportion of the western animals are placed in feed lots for increased finish.

In contrast to the location of the production areas we find the consumption areas in the eastern part of the nation. About 80% of the population resides east of the Mississippi, while about 50 percent live in the sixteen states east of the Mississippi and north of the Ohio and Potomac Rivers and slightly less than thirty percent in the fifteen states from Minnesota south through Louisiana and south of the Ohio and Potomac Rivers.

Due to the location of the consumers, and the relative cost of shipping live animals versus refrigerated meat in the past, most of the slaughter houses and packing plants have been established in the East, or in large mid-western cities along main water ways.

Principle items of marketing costs include: (1) transportation, (2) yardage, (3) feed, (4) deaths, (5) crippling, (6) selling and/or buying, (7) insurance and (8) shrinkage.

Shrinkage of cattle will be the center of investigation in the following analysis. This has been chosen because the information available to the public is not adequate, and there has been very little previous work done with the shrinkage problem.

Shrinkage in this study has reference to the loss in weight which occurs between the point of origin (loading point) and the destination of

1/ Wilcox, R.H., Jennings, R.D., Collier, G.W., Black, W.H., McComas, E.W., Costs and Methods of Fattening Beef Cattle in the Corn Belt, 1919-1923, U.S.D.A. Technical Bulletin 23, December, 1927, p. 2.

the animals, or the difference in weights between two time periods whether shipping takes place or not. This loss in weight may be due to excretory shrinkage or tissue shrinkage.

"Excretory shrinkage is defined as the loss in weight resulting from the elimination of excreta, which is usually referred to as the elimination of "fill". The decrease in the dressed body weight of the animal is the result of tissue shrinkage. An animal that has been fed and watered shortly before it is sold is referred to in the trade as having been "filled", the degree of "fill" being dependent upon the amount of feed and water that the animal retains when weighed. When most of the intestinal and bladder contents have been excreted, the animal is referred to as having had the fill "eliminated", or the animal is "shrunk out".

Dressing yield, as determined by the packers, represents the percentage that the weight of the dressed carcass of the slaughtered animal is of the live weight at the time the animal is purchased. For example, if a steer weighing 1,000 pounds alive produces a carcass weighing 550 pounds, the dressing percentage or yield is fifty-five percent.

The extent, therefore, to which an animal is filled when it is purchased affects its dressing yield. An animal with heavy fill yields a smaller percentage of carcass than one purchased without fill. The amount of fill will affect the live weight of the animal, but it will not affect the carcass weight, and it is the carcass weight that the packer estimates when he buys livestock. Loss in weight resulting from tissue shrinkage, on the other hand, constitutes an actual reduction in the carcass weight.^{1/}

Although both of these types of shrinkage constitute a loss in weight, the excretory shrinkage can be replaced rather soon whereas the tissue shrinkage takes a longer period of time to replace, because the feed must be converted into animal tissue.

These two types of shrinkage probably do not occur as two distinct

^{1/} Dowell, A.A. and Bjorka, K., Livestock Marketing, McGraw-Hill Book Company Inc., London and New York, 1941, pp. 240-41.

phases in the shrinkage process. The shrinkage due to loss of stomach fill still may be taking place when the shrinkage due to loss of tissue weight is beginning. Therefore, at one stage in the process, there may be a rather heavy amount of total shrinkage since both types are possibly occurring at once. The two types shade into one another, but on each extreme only one type of shrinkage occurs. In the early part of the shipment only excretory shrinkage occurs. At a certain undefined stage in the shipment both excretory and tissue shrinkage occurs. During the latter part of the shipment only tissue shrinkage occurs after all of the stomach fill is lost.

Information on the amount of shrinkage expense as related to the total cost of marketing livestock is inadequate, but there are some data available on shrinkage as a proportion of total shipping costs. Nervick, in his study of marketing South Dakota cattle, found that shrinkage is very important relative to other marketing costs. It was found in his case study that shrinkage was responsible for the greatest part of expenses incurred when shipping yearling steers.

Shrinkage on these cases varied from 6.8 percent for a shipment of calves which covered a distance of 465 miles to 12.2 percent for a shipment of yearling steers which covered about 750 miles. These figures are somewhat misleading because the stock in all cases had been off feed and water before weighing at origin. Thus a considerable shrinkage had already occurred before the first weights were taken. Assuming a given price level, shrinkage still remains the most important element in total shipping costs. In these cases it varied from 69 to 80 percent of the

total transportation costs. It is, therefore, of great importance to livestock shippers that serious efforts are made to reduce such losses. (See Table II).

People (producers of livestock and consumers of meat) do not realize the importance of shrinkage, neither do they know what factors are responsible for shrinkage, nor what factors can, and should, be controlled to reduce shrinkage.

Shrinkage is one of the major factors that the livestock dealers and buyers consider when purchasing animals. The returns to the producer per animal are determined by the price of the animal per pound times the weight in pounds of the animal. Shrinkage is a partial determinant of both price and size of animal. If the animal has been "shrunk out" there may be a higher price per pound offered. If the animal has not been shrunk out there will be more pounds of beef to offer for sale. The buyer will try to estimate each case into an equality of final total payment. This ability of the buyer to make correct estimates determines in part whether or not he will make any net return on his business. This variation in shrinkage then, is realized by the dealers to be one of the most important factors to be considered. Therefore, shrinkage becomes a bargaining point along with price for determining what is to be paid for the animals. Since it is the buyers profession to deal in livestock he will tend to become very practical at figuring shrinkage percentages, and it may be to the producer's detriment if he does not realize the importance of shrinkage. In addition the buyer may lack competition in certain markets, or if competition for purchases is high it may be biased towards

Table II. Cost of Transportation for Yearling Steers, Kilgore, Nebraska, to Montecello, Iowa. Basis Loading Weights, 1949.

Average price per cwt.	Freight rate per cwt.	Feed costs per cwt.	Percent Shrinkage	Cost of shrinkage per cwt.	Total shipping costs per cwt.	Shrinkage as % of total shipping costs
\$21.65	\$.581	\$.026	8.7	\$1.883	\$2.49	75.6

Source: Marketing South Dakota Feeder Cattle, Agricultural Experiment Station, Brookings, South Dakota, Bulletin 409, May, 1951, p. 13.

the normal shrink, rather than towards an equality of payment throughout the shrink range. These factors all serve as bargaining points for purchase of the animals.

There are numerous factors which have been assumed in the past to be responsible for shrinkage. Some of those which have been assumed to influence the weights of the animals are: length of journey, degree of comfort en route, season of the year (temperature), type of transportation, number of animals in car, age of animal, class of animal, breed of animal, sex, size, progeny, feed before--during--and after shipment, water availability and freshness, number of feed and rest stops, number of hours at feed and rest stops, and handling before--during--and after shipment. From this list it may be seen that relatively little is actually known about which are the more important factors in determining shrinkage. The size of the list illustrates that shrinkage may be due to a large variety of factors. Prior to controlling at random any one or even a few of these factors, it would be wise to determine the relative

importance of each and then emphasize the control of the most important.

Under present conditions it is entirely possible that western sellers are forced to accept an unnecessarily high price discount by buyers to cover anticipated heavy shrinkage and other losses when possibly such discounts are unwarranted. It is also believed that certain segments of the trade (not including livestock producers) have available certain factual information on shrinkage which is not at the disposal of growers generally.

Ranchers and farmers are at a competitive disadvantage when they buy and sell stock, because they lack adequate information on shrinkage. More information is available to the other segments of the livestock trade. If the people other than the producer have knowledge about amounts of shrinkage, variations in shrinkage and effects of shrinkage on profits, then they will have the advantage over the producer who does not have this specific knowledge of shrinkage. The producer therefore will base his market position (price asked) on less definite grounds than does the competition.

The dynamic nature of the western livestock and meat industry including the production and marketing, as well as the demand for these products, present some real problems in the area of efficient use and economic allocation of western resources. Because of the rapid changes which have occurred it is entirely possible that the movements and methods of handling live animals are not in accord with the most efficient patterns of livestock sales distribution. It is also likely that through custom, established industry practices or because of other rigidities in the trade, present methods of handling and moving livestock to market are not

in accord with the best or the most efficient marketing procedures.

C. Hypotheses

The following statements are possible solutions to the shrinkage problem which must be put to the test of experience. They go beyond the given arrangement to a possible interpretation of the patterning of relevant facts. These possibilities are projected provisionally, with a definite view to ultimate confirmation or rejection after testing. These possibilities will be tested by the use of empirical evidence and theoretical tools.

Hypothetical Statements -

1. There is a loss to society as a whole due to tissue shrinkage.
Excretory shrinkage may result in no social loss but a transfer of income from one individual to another depending upon the knowledge and bargaining ability of the parties connected with the trading of animals.
2. Many factors are responsible for shrinkage.
3. Something can be done to reduce shrinkage, and to keep all parties informed relative to the extent of shrinkage that does occur.
4. There is an excessive shrinkage of cattle in transit and a reduction in this shrinkage can be economical. Returns obtained from additional weight will be greater than the costs incurred in obtaining this additional weight.

D. Objectives of the Investigation

1. To determine the amount and importance of shrinkage of various classes of cattle.
2. To find out what factors are responsible for shrinkage and to determine the relative importance or significance of a selected few of these factors.
3. To set forth economic criteria which might reveal the extent to which these factors can be controlled in order to reduce shrinkage.
4. To set forth economic criteria by which the extent of social loss due to shrinkage might be tested.
5. To estimate the economic feasibility of reducing animal shrinkage and suggest action that would bring about economic optimum conditions.

E. Boundaries and Limitations

This study will deal only with the shrinkage part of the marketing costs of beef cattle. It will not include any analysis of other marketing costs as such but it may use some of these costs in order that the extent and importance of shrinkage costs can be illustrated.

This study will not deal with livestock other than cattle, and it will not include any information on stock which are not of a beef breed.

The scope of this study will include only stock produced or handled in Montana. Due to the lack of historical records on shrinkage, time limitations must be recognized. Most of the statistical information used

is obtained on the sale of beef steers from the Branch Experiment Stations at Havre and Miles City, Montana, but also included will be other data to supplement this when it is necessary to illustrate important problems.

In the empirical analysis an investigation of all of the factors believed to influence shrinkage will not be made; but the analysis will center upon those factors which are believed to influence shrinkage the most or those factors about which the least is known.

Research results will be presented in a manner unbiased towards any particular segment of the livestock industry. The details of the situation as they exist will be presented as completely as the limits of the research will permit.

F. Review of Literature

The shrinkage problem has not received great attention, probably due to the difficulty of obtaining accurate data from the shippers. It is often impracticable to obtain loading weights necessary for shrinkage calculations, particularly for grass fat and feeder animals shipped from summer ranges. Often there are no livestock scales available at shipping stations in such areas. In addition, many shipments are trailed several miles over a period of a day or days to reach the loading point, and few ranches have scales at the original starting point. Without scales it is impossible to determine this first shrinkage which has, in a few cases, been proven greater than shrinkages in subsequent periods. Some shippers are reluctant to expend time and effort necessary to weigh and keep records of shipments even if it were possible, because they figure the loss

is unavoidable, and that a record of shrinkage would be valueless.

Available reports on shrinkage studies are very limited but a brief review of those available will lend clarity to the problems associated with a study of shrinkage.

W. F. Ward and James E. Downing made one of the most complete studies of cattle shrinkage that has been made in the last 50 years. ^{1/} Their study was divided into three main parts: (1) Southwestern Shrinkage Work of 1910-11, (2) Northwestern Shrinkage Work of 1911-12, (3) Northwestern and Southwestern Shrinkage Work of 1911. The cattle used in making this investigation were raised in different parts of the West. The range cattle work was carried on in the various Western States from Texas to Montana, and the work with the fed cattle was confined chiefly to the States of the Middle West. No intentional discrimination was made against any section but the work was done where the conditions were most favorable for it.

The objectives of the work of Ward and Downing may be briefly stated as follows: (1) To secure weights of enough cattle of each class in order that comparisons could be made of the shrinkage of one class of cattle with another for a given period of time. (2) To determine, if possible, at what period of the journey the greatest shrinkage occurred. (3) To study what effects the different methods of handling the cattle previous to loading them had upon the shrinkage in transit. (4) To note the effect of the weather at time of shipping upon the shrinkage in transit and the fill

^{1/} Ward, W.F. and Downing, James E., United States Department of Agriculture, Bureau of Animal Industry, The Shrinkage in Weight of Beef Cattle in Transit, (December, 1913), p. 71.

taken at market. (5) To determine the relative benefit, if any, of a good, quick run to market as compared to a slow, rough trip with careless handling of the train. (6) To see whether or not feeding and watering the cattle a short time before loading them was beneficial. (7) To note the difference in shipping cattle long distances in "feed and water" cars without unloading them, as against the method of unloading in transit to feed, water, and allow the stock to rest. (8) To study the shrinkage of cattle that have been finished for the market upon various feedstuffs. (9) To note what influence the season will exert upon the shrinkage. (10) To obtain reliable data that may be used as a basis upon which the cattlemen can calculate the approximate shrinkage in weight of his cattle in shipping.

The weights of the animals were taken at the point of loading, on arrival at their destination, and again after having been given rest, feed, and water. The last weight was the weight secured when the animals were sold. Conditions surrounding the cattle previous to shipment, en route, and at destination, were recorded. Any other items of importance were also noted.

The three years' work may be briefly summarized as follows:

(1) The shrinkage of cattle in transit depends very materially upon: (a) the conditions existing at the time of shipping and upon the treatment received during the drive to the loading pens, (b) the length of time the cattle were held without feed and water before being loaded, (c) the nature of the fill which the cattle had before loading. If it was of succulent grass, beet pulp, or silage, a great loss in weight was experienced, (d) the weather conditions at the time of loading and while

in transit, (e) the character of the run to market. Slow, rough runs caused a great shrinkage, (f) the kind of treatment they received at unloading stations, (g) the time of arrival at market, if they arrived just before being sold, the fill was small. Cattle that were shipped a long distance and those that arrived at market during the night before sale usually did not fill well. If they arrived the afternoon before or about daylight of the sale day, they generally took a good fill, (h) the climatic conditions at the market.

(2) An exceedingly large fill at market is not desired, as it will detract from the selling price.

(3) The shrinkage on calves may seem small, but under normal conditions it holds about the same proportion to their weight as is found with grown cattle.

(4) The difference between the shrinkage of cows and steers is not as great as many in the trade supposed. Steers will usually shrink somewhat less than cows of the same weight.

(5) The shrinkage during the first 24 hours is greater proportionately than for any succeeding period of the same duration.

(6) The number of pounds lost by shrinkage in cattle was found to vary in direct proportion to their live weight when conditions were the same and all other factors were equal.

(7) The shrinkage of range cattle in transit over 70 hours during a normal year is from 5 to 6 percent of their live weight. If they are in transit 36 hours or less, the shrinkage will range from 3 to 4 percent of their live weight.

(8) The shrinkage of fed cattle does not differ greatly from that of range cattle for equal periods of time.

(9) Cattle fed on silage have a large gross shrinkage but usually fill so well at market that the net shrinkage is small.

(10) Pulp fed cattle shrink more in transit than any other class of cattle, and also incur a greater net shrinkage.

(11) The shrinkage of cattle is proportionately smaller for each additional twelve hours they are in transit after the first 24 hour period is past.

(12) For a long journey the common method of unloading for feed, water, and rest is to be preferred to the use of feed and water cars. Cattle should be weighed before being loaded wherever practicable, to obtain net shrinkage.

Among other articles available on small surveys which have been made recently is a report by Jacobsen and Willson who conducted a preliminary study of feeder calves. Their study supplied good evidence in regard to the extent of shrink that occurs and factors influencing shrinkage. ^{1/}

The purpose of this study was to determine the cost of shipping, including the amount and cost of shrinkage on a shipment of feeder calves from Montana to Ohio. An observer accompanied the shipment and noted conditions of delivery to railroad shipping point, weighing, loading, railroad handling, and feeding en route, delivery and weighing at final

^{1/} Jacobsen, N.A., and Willson, E.A., Marketing Costs of Feeder Calves Montana to Ohio, Montana Experiment Station, July, 1949, Unpublished data.

destination and sorting for grade after arrival. All conditions were noted which are believed to contribute to the shrinkage of livestock in transit.

In this study it was found that shrinkage costs accounted for about 69.2% of total shipping costs. The information secured in this study indicates the need for further investigation of controlled shipments handled under varying conditions.

Abbenhaus and Penny made a study, the purpose of which was to determine how much shrinkage occurs in transporting fat cattle to market and during what part of the haul the greatest amount of shrinkage takes place. ^{1/} In this study there were 75 head of fat steers loaded in trucks and hauled 200 miles. These steers were weighed when loaded and also after 25, 50, 100, and 200 miles of the haul. Sixty steers averaged 44.3 pounds of shrink per head. Average percent of weight shrinkage was 3.9%. This study shows that shrinkage for fat cattle in transit takes place at an extremely rapid rate in the first part of the haul, 46.3% in the first 1/8 of the trip, and after the first 25 miles shrinkage occurs at a rapidly decreasing rate.

Nervik reported that shrinkage of cattle during marketing represented 75.6% of total marketing costs. His investigation was designed to obtain information about the channels of distribution for cattle from range to feedlots. In transporting the cattle from the producer to the market, the

^{1/} Abbenhaus, Gerald R., and Penny, Roland C., Shrink Characteristics of Fat Cattle Transported by Truck, Chicago Union Stock Yard and Transit Company, Chicago, Illinois, 1951.

costs of transportation were observed. Since shrinkage was found to represent about $3/4$ of the shipping costs, it was observed that the greater the shrinkage rate, the greater were the total marketing costs. 1/

Wright compiled research material which had been released by other people concerned with the field of livestock shrinkage. 2/ He found that shrink varied according to the action of many factors. These factors were: time, conditions and methods of weighing and computing shrinkage, nature of feed previous to shipment, condition of animal previous to shipment, time en route to market, and weather conditions during journey. In view of the factors found in his analysis, Wright recommends that: (1) shippers should know how much shrink occurs, (2) animals should be handled carefully, (3) time en route should be decreased, and (4) rail cars and trucks should be well sanded and bedded.

1/ Nervick, Ottar, Marketing South Dakota Feeder Cattle, Bulletin 409, Agricultural Experiment Station, Brookings, South Dakota, 1951.

2/ Wright, J. Stewart, Montana Sheep and Cattle Shrinkage in Transit, Montana Experiment Station, May, 1942.

PART II.

EMPIRICAL ANALYSIS

A. Methodology

The following section is comprised of statistical data designed to test the projected hypotheses and attain the objectives of the study as fully as possible. Data are tested and analyzed by statistical measures as an aid in the determination of the extent to which the hypotheses can be substantiated or rejected. The empirical data are used to measure the extent of shrinkage that takes place in cattle of different age and sex classes. The information is also used in the determination of factors responsible for livestock shrinkage, and their relative importance. The relative importance of proposed major factors are measured by means of correlation analysis, and the functional relationship between the factors causing shrinkage and the extent of shrinkage is illustrated and described.

The major portion of the data used in this section is information compiled from the records of the Branch Experiment Stations at Havre and Miles City, Montana.

The information from Havre is on steers which have had uniform treatment in the production and feeding process. A record is kept of each animal from birth to the time of sale. The animals are born early in the spring of the year and run with their mothers on range grass until the following fall, at which time they are weaned and placed in feed lots. They remain in the feed lots from the autumn until early in the next spring season when they are shipped by rail to the South St. Paul Central

Market and sold through a commission firm. The animals produced at the Miles City station are handled approximately the same as those from the Havre station. The major difference between the two being the fact that the Miles City steers are sold later in the year, generally in July. Otherwise, there is no significant difference in production procedures between these two groups of cattle.

Additional information has been obtained from private producers and dealers throughout the state of Montana. This information was obtained by personal interviews with ranchers and dealers who had recently handled a livestock transaction and had the data required available for use. 1/ It was necessary to obtain additional material in order that the extent of shrinkage could be observed in animals other than slaughter steers which were produced by the Experiment Stations. This supplementary data was obtained on animals of different ages and sexes, as well as on animals which varied greatly in degree of finish from each other and from the Havre and Miles City animals.

The data obtained will of a necessity have limited uses because of incompleteness relative to many shrinkage aspects.

The statistical analysis is used as a basis for determining factors which may be controlled as a means of reducing shrinkage. In addition, for these factors responsible for shrinkage, it may be used to determine the extent of control which is economical, and to determine the optimum range or point at which control should be maintained. Another use for

1/ See appendix for a copy of the schedules used.

these data is to determine, if possible, whether or not there is a loss to society initiated through extensive shrinkage of cattle.

B. Extent of Shrinkage

One of the questions which has arisen in the past and also in relation to this study, is how much shrinkage of different classes of animals takes place during marketing? How much shrinkage should a producer expect when shipping animals under a variety of conditions? Which class of animals shrinks the most? What is the relationship between age and the extent of shrinkage? How much variation of shrinkage is there within classes of animals under similar treatment? An attempt is made in the following divisions to answer these questions with respect to calves, cows, and yearling steers and heifers.

1. Calves

Calves are generally taken from their mothers at an age of 4 to 7 months and sold immediately. Calves are expected to shrink a little more than other animals because of extreme nervousness occasioned by separation from their mothers.

When calves are taken from their mothers they are taken off their major source of feed. The feed that they have been accustomed to is no longer available, and an abrupt change is necessary in order that they will not starve. Of course, this means that there will be a considerable length of time before the calves will fill up enough on hay and water to slow down the rapid shrinkage taking place. Even if they do adapt themselves to the new feed, they will not eat adequately to stop shrinkage because of

worry and nervousness due to the loss of their mother's companionship. High shrinkage is especially noticeable on calves which are shipped long distances. Heavy shrinkage was quite noticeable in the study made by Jacobsen and Willson in their observation of feeder calves shipped from Montana to Ohio. ^{1/} The figures relevant to the shrinkage in this case are shown in Table III.

These figures indicate that the shrinkage was relatively high, and also that heifer calves in this case shrunk just slightly less than did steer calves.

Table IV presents figures on calves which were shipped by rail from range in Montana to several different markets. These shrinkage figures are based on the difference between the loading weights of the calves and the off-car weights of the calves. This would mean that the calves had no time for refill before the final weight was taken. These calves ranged from 5.7% shrink to 12.6% shrinkage. The average shrinkage was 8.8% of loading weight.

The conditions surrounding these shipments were approximately the same as those outlined in Table V below, with the exception of the difference in the weighing conditions. Table IV is based on loading weight and off-car weight, while Table V is based on loading weight and sales weight, or weight after fill-back.

The shrinkage figures in Table V were obtained on the difference between loading weight of the calves and sales weight of the calves. The

^{1/} Jacobsen, N.A., and Willson, E.A., Marketing Costs of Feeder Calves Montana to Ohio, Montana Experiment Station, July, 1949. Unpublished data.

Table III. Shrinkage of Feeder Calves Shipped from Montana to Ohio ^{1/}

No. of animals	Total shrink	Per head shrink	Percent shrink
82 steers	4,425 lbs.	54.0 lbs.	12.6
45 heifers	1,965 lbs.	43.6 lbs.	11.2
TOTAL: 127 head	6,390 lbs.	50.3 lbs. ← Average → 11.9	

Table IV. Shrinkage of Montana Calves Determined by the Difference in Loading and Off-car Weights, and Transported by Rail to Market.

Origin	Destination	Hours En Route	Number of head	Loading Weight	Percent Shrink
Miles City	Greeley, Colo.	96	200	332	5.7
Toston	Greeley, Colo.	120	120	427	6.6
Ross Fork	Sioux City, Iowa	72	34	415	8.0
Ross Fork	Greeley, Colo.	144	70	404	8.3
Idaho Falls, Idaho	Gallatin Gateway, Mont.	48	500	423	9.0
Ringling	Arlington, Wis.	108	291	334	9.9
Lewistown	Greeley, Colo.	120	100	434	10.6
Whitehall	Greeley, Colo.	120	151	397	12.6
	AVERAGES	108	163	397	8.8

Source: Data gathered in cost of marketing study at M.S.C., 1952-53.

shrink ranges from .5% to 13.3% for the animals observed in these shipments. The average shrinkage was 3.5% for calves shipped by rail, while the calves shipped by truck averaged 5.1%. This leaves a difference of 1.6%. With

^{1/} Ibid, p. 12.

Table V. Shrinkage of Montana Calves, Determined by the Difference Between Loading and Sales Weight. Transported by Rail and by Truck.

Transported by Rail ¹							Transported by Truck						
Origin	Destination	Hrs. En Route	No. of Head	Hrs. in Yards Before Sale	Loading Weight	Per-Cent Shrink	Origin	Destination	Hrs. En Route	No. of Head	Hrs. in Yards Before Sale	Loading Weight	Per Cent Shrink
Missoula	Twin Falls	120	121	*	448	.5	Dell	Idaho Falls	9	150	30	369	.8
Lewistown	Chicago	72	68	120	465	1.1	Dillon	Dell	1	19	#	465	1.5
Lewistown	Chicago	96	220	96	425	1.7	Dillon	Dell	2	*	#	408	2.0
Dell	Idaho Falls	11	54	30	463	2.3	Roscoe	Billings	2	20	4	480	6.3
Ross Fork	Sioux City	72	34	48	415	4.1	Two Dot	Billings	4	27	1	423	7.1
Dell	Idaho Falls	10	47	34	395	4.3	Two Dot	Billings	4	2	1	300	13.3
Dillon	Denver	48	132	216	430	5.2							
Billings	Denver	48	130	*	396	5.3							
Cascade	Sioux City	168	91	*	339	5.3							
Lewistown	Chicago	84	72	120	420	5.5							
	Average	73	97	95	420	3.5		Average	3.7	44	9	406	5.1

* Data not available.

No time in yards

Source: Data obtained for cost of Marketing Study, M.S.C., 1952-53

the exclusion of the shipment which shrank 13.3%, which were influenced by a bad snowstorm, from the truck shipments, the average becomes 3.8% for calves shipped by truck. This leaves a difference of .3% between the shipments transported by rail or truck. This difference is rather insignificant and the conclusion may be drawn that calves shipped by rail or truck will average approximately 3.7% shrinkage. | This is made with the assumption that other shipments will be comparable to these in surrounding conditions. These conditions may be listed as an average of 73 hours en route by rail and 3.7 hours by truck, an average feeding period between arrival at yards and sale of animal of 95 hours on those shipped by rail and 9 hours on those shipped by truck, and animals which averaged approximately 413 pounds loading weight.

This gives a difference of 4.6% average shrinkage between calves allowed to refill and those not allowed a refill. The difference seems to be significant, especially since the conditions surrounding both sample groups were comparable, with the exception of the weighing conditions as has been outlined above.

2. Cows

Cows are generally sold when they are no longer milking and are to be culled from the breeding herd. Thus, they are called "dry" cows. Dry cows are sold as feeder or slaughter animals depending upon their relative condition. The extent of shrinkage in dry cows in relation to hours in yards before sale is outlined in Table VI and figure 1.

Table VI shows the extent of shrinkage in dry cows in Montana as it

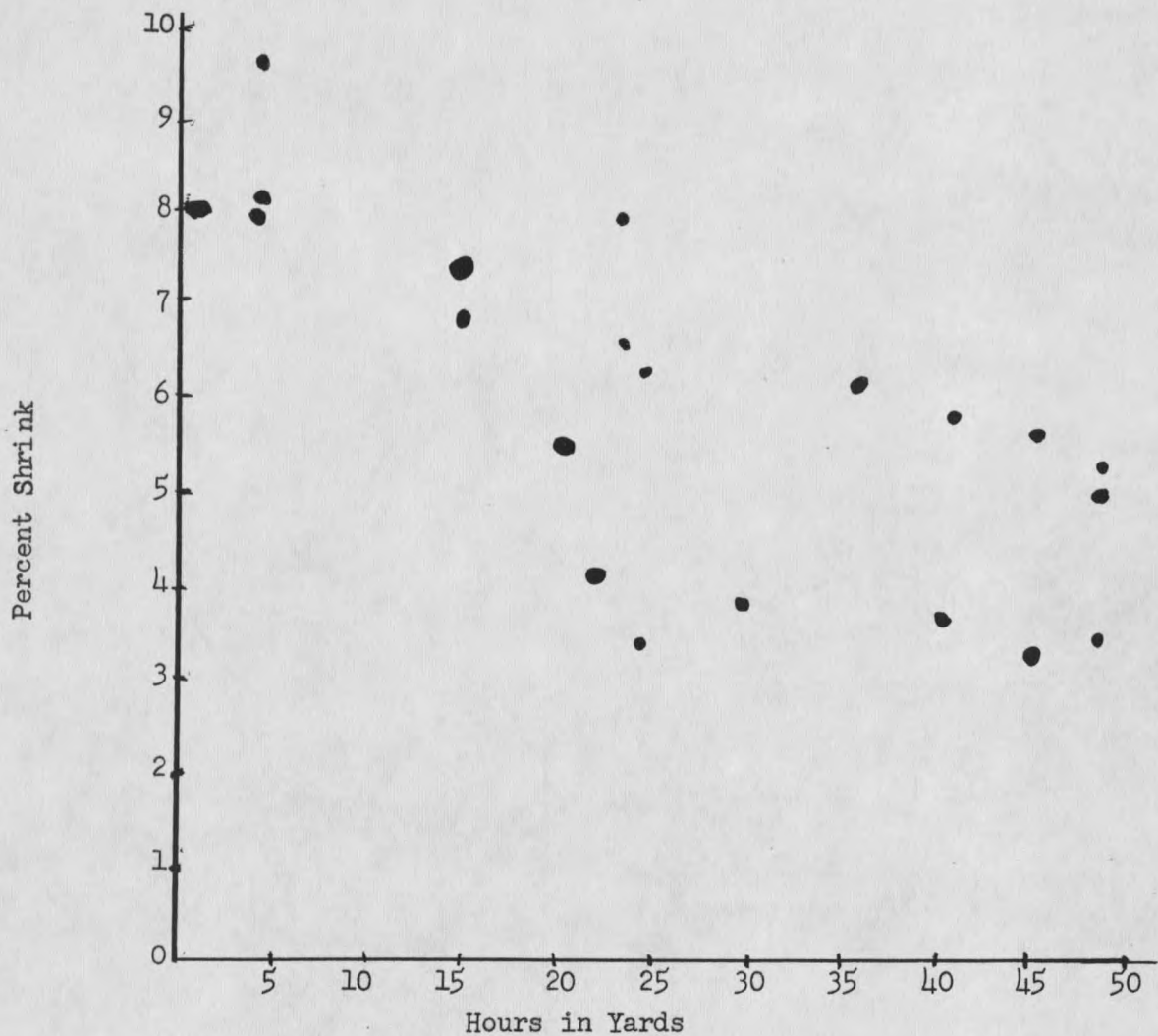


Figure 1. Scatter Diagram Showing the Percent Shrink of Dry Cows in Relation to Hours in the Yards Between Arrival and Sales.

is related to the hours in yards between arrival and sales. This is an allowance of time for the animals to obtain a refill before the sale takes place.

The shrinkage ranges from 3.5% at 24 hours in the yards to 9.5% at 4 hours in the yards. The average shrink is 5.9%. The average number of

Table VI. Shrinkage of Dry Cows in Montana, Based on the Difference Between Loading and Sales Weights.

Origin	Destination	Hours En route	No. in Shipment	Loading Weight	Hrs. Between Arrival and Sales	Percent Shrink
Dell, Mont.	Butte	4	11	1136	24	3.5
White Sulphur Springs	Butte	24	18	1375	45	3.6
Gallatin Gateway	Butte	4	3	1186	40	3.7
Two Dot	Billings	4	2	1435	48	3.8
*	Billings	2	1	1160	30	3.9
Ranch at Glasgow	Glasgow	1	96	1145	21	4.0
Dillon	Idaho Falls, Idaho	7	13	1167	48	5.1
White Sulphur Springs	Butte	24	2	1255	48	5.4
Colestrip, Mont.	Bozeman	29	1	1180	45	5.5
Harlowton	Billings	4	10	1282	20	5.5
Gallatin Gateway	Butte	4	1	1420	40	5.6
Fish Tail, Mont.	Billings	2	10	1325	36	6.0
Harlowton	Billings	3	3	1183	24	6.3
Harlowton	Billings	3	4	1265	23	6.5
Fish Tail, Mont.	Billings	3	2	1600	15	6.9
Fish Tail, Mont.	Billings	2	7	1100	15	7.5
Absorakee, Mont.	Billings	2	2	1027	22	7.8
Hamilton	Missoula	2	19	1200	0	8.0
Hamilton	Missoula	2	9	1100	4	8.0
Hamilton	Missoula	2	14	1200	4	8.0
Gallatin Gateway	Butte	4	1	1420	4	9.5
	Averages	6.3	10.9	1245.8	26.5	6.4

* Not obtained

Source: Data from Cost of Marketing Study at M.S.C., 1952-53

hours in the yards was 26.5.

Shrinkage decreases as the number of hours in the yards increases. (figure 1). In other words, the longer the cows are fed in the yards previous to sale, then the less will be the amount of net shrinkage that takes place. 1/ Before arrival at the yards the cows were en route an average of 6.3 hours, which seems quite representative of the group.

3. Steers and Heifers

These classes of animals are sold either combined, or separately. Generally they are sold from the range in Montana when they are "long yearlings" about 16 to 20 months of age. This class has tended to include the majority of the animals sold from the arid regions of the state, since in these areas less hay and grain are available for the required winter feed. Consequently, the animals are sold after only one winter's feeding. The recent trend has been towards an increasing number of ranches going on to the cow and calf basis where the calves are sold before any winter feeding is required. Nevertheless, most of the cattle sold in Montana at the present time are sold as long yearlings. 2/ These cattle are sold as feeder stock to the corn belt, Pacific coast, or other feeder areas, or as grass fat slaughter animals.

1/ The regression equation for this relationship is $Y = 8.018 - .08X$ and the gross correlation coefficient is $r = -.73$ while the gross coefficient of determination is $r^2 = .53$. The correlation coefficient is significant at the 99% level.

2/ Stevens, Ira M., et al, Marketing Western Feeder Cattle, Wyoming Agricultural Experiment Station, Bulletin No. 317, Laramie, Wyoming, June, 1952 pp. 19, 20.

When animals are allowed time for a refill, the shrinkage may be reduced considerably. According to material that has been gathered with respect to feeder heifers and steers, it has been observed that they shrink approximately 3.5 percent and 4.4 percent, respectively. (See Table VII). The actual shrinkage seems to be partially determined by the number of hours en route and the number of hours in the yards previous to sale. The heifers which increased their weight .9% were enroute only 2 hours, and in the yards 10 hours before sale, whereas the heifers which shrank 7.3% were en route 2 hours and in the yards only 1 hour before sale took place. (Table VII). Obviously, there is some relationship between these two factors with respect to feeder heifers. Feeder steers average approximately 4.4% shrinkage when allowed a reasonable length of time for refill. Overnight shrink on a group of 63 steers was found to be 3.8% as is shown in Table VII. Feeder heifers have a little advantage over feeder steers since heifers averaged 3.5% while steers average 4.4%, a difference of .9%. These figures seem to be comparable since the conditions of time en route and hours allowed for a refill are very nearly equal.

Slaughter steers shrink a little more than slaughter heifers according to data presented in Table VIII. Heifers shrank 2.3% less than steers even though they were en route 49 hours in contrast with 23 hours for the steers. Although the difference of 2.3% may be due to other factors not listed, it would suggest that there is a difference in shrink that might be expected between slaughter steers and heifers. The significance of other factors is suggested by the fact that in the steer group with a constant number of hours en route, the shrink varies from 4.2% to 10.0%.

Table VII. Shrinkage of Montana Feeder Heifers and Steers, Based on the Difference Between Loading and Sales Weights.

Feeder Heifers					Feeder Steers				
Hours En route	Number in Shipment	Loading Weight	Hours in Yards Before Sale	Percent Shrink	Hours En route	Number in Shipment	Loading Weights	Hours in Yards Before Sale	Percent Shrink
2	88	512	10	4.9	100	25	660	72	6.9
100	9	561	72	4.4	29	1	680	48	7.4
29	1	600	48	5.8	29	27	689	48	.5
40	6	638	32	2.7	163	38	727	6	7.7
4	20	697	48	6.0	2	7	733	3	3.5
4	3	773	40	3.4	0*	63	784	0	3.8
2	8	803	1	7.3	4	16	840	48	5.2
29	4	908	48	4.7	8#	290	856	0	1.3
					72	209	887	72	4.5
					2	32	1015	18	2.5
					4	18	1054	18	4.5
Ave 36	17	687	37	3.5	38	66	811	30	4.4

* Overnight shrink

Trailed

Source: Data obtained from the Cost of Marketing Study, M.S.C., 1952-53.

Also in the heifer group, with time en route held constant at 36 hours, shrinkage is seen to vary from 3.8% to 5.0%.

Shrinkage of Montana feeder steers in transit averages about 9.0% as is indicated in Table IX. Many of these animals were shipped a relatively long distance. The shrink ranges from 1.0% to 17.3%. The low shrinkages tend to be combined with short hauls while the higher shrinks are probably due to comparatively long hauls.

When analyzed statistically the relationship between shrinkage and hours en route is shown by the regression equation $Y = 6.34 + .026X$. This means that, when Y denotes shrink and X denotes hours in transit, an increase of one hour en route will result in a corresponding .03% increase in shrinkage. When the animals are shipped 100 hours the shrink will increase approximately 3%. The degree of the relationship is shown by the correlation coefficient, $r = + .41$. ^{1/} The proportion of the variability in shrinkage which is explained by hours en route is illustrated by the coefficient of determination r^2 which is equal to .17. From this figure it is seen that about 17% of the variation in shrinkage is explained by variations in hours en route. This leaves 83% of the variation to be explained by factors other than hours en route.

If the animal shrinkage, computed on the difference between loading and off-car weights, is compared with the shrinkage figured on the difference between loading and sales weight, it can be seen that those animals

^{1/} These figures are significant at the 95% level, which means that the chances are 5 in 100 that the correlation coefficient would be this high due to chance alone.

Table VIII. Shrinkage of Montana Slaughter Heifers and Slaughter Steers --- Based on the Difference Between Loading and Off-Car Weights.

Slaughter Heifers				Slaughter Steers			
Hours En route	Number in Shipment	Loading Weight	Percent Shrink	Hours En route	Number in Shipment	Loading Weight	Percent Shrink
36	31	798	3.8	36	32	884	10.0
36	34	805	4.0	36	31	987	5.0
36	31	828	4.0	36	26	1064	4.2
36	32	834	4.0	2	20	1100	4.0
36	10	838	4.0	2	13	1100	5.0
36	30	870	4.5	48	336	1136	8.8
36	30	870	5.0	3	11	1185	5.2
140	8	914	8.5				
Ave. 49	26	845	4.7	Ave. 23	67	1065	7.0

Source: Data obtained for the Cost of Marketing Study at M.S.C., 1952-53.

Table IX. Shrinkage, of Montana Feeder Steers, as a Percent of Loading Weight—Based on the Difference Between Loading and Off-Car Weights.

Number in Shipment	Hours En route	Loading Weights	Off-Car Weights	Percentage of Shrink
113	72	503	429	14.5
45	26	626	577	7.8
25	100	660	615	6.9
88	192	676	613	9.3
23	140	682	615	9.9
133	108	698	630	9.7
48	3	703	692	1.6
557	140	714	629	10.2
38	163	727	647	11.0
101	108	750	685	8.7
143	140	772	689	10.7
211	108	809	707	12.6
360	100	844	747	11.3
58	135	851	704	17.3
34	156	860	766	10.9
188	140	904	836	7.6
99	140	908	803	11.6
65	3	979	958	2.2
114	140	1062	990	6.8
322	120	1094	1001	8.5
13	2	1100	1045	5.0
155	108	1132	1089	12.6
88	20	1135	1089	4.0
150	1	1148	1117	2.7
233	140	1170	1050	11.0
139	168	1190	1073	9.9
Average = 136	103	873	800	9.0

Source: Miscellaneous data obtained in the Cost of Marketing Study, Montana State College, 1952-53.

of the first group shrank a good deal more than did those in the second group. (See Table X). The calves, shipped for a period of 215 hours underwent the greatest amount of shrinkage (11.9%) on an off-car difference, while feeder steers averaged 9.0%, other calves 8.8%, slaughter steers 7.0%, and slaughter heifers 4.7%.

When shrinkage is computed on the difference between loading and sales weight, cows accumulated the highest shrinkage with an average of 6.4%, next were feeder steers 4.4%, calves 4.3%, and feeder heifers 3.5%. (See Table X).

From the factors which have been observed it seems that there is a slight tendency for percent shrinkage to increase with a decrease in loading weight, and to decrease with an increase in loading weight. (See feeder steers in Table VII). This tendency was also shown in the study made by Abbenhaus and Penny in checking shrinkage of different weight classes. 1/

A tendency for the shrinkage to decrease with an increased length of time in the yards previous to sale is also noticeable. (See correlation estimates on page 36). There is a positive relationship between percent shrink and hours en route. This is illustrated by the regression equation and the correlation coefficients on page 39 of this study.

Any and all of these shrinkage figures in Table X may vary considerably with variations in any of the factors listed, such as: class of

1/ Abbenhaus, Gerald R., and Penny, Roland C., Shrink Characteristics of Fat Cattle Transported by Truck, Chicago Union Stock Yard and Transit Co., Chicago, Illinois, 1951, pp. 5-7.

Table X. Shrinkage of Various Classes of Cattle in Montana. Gross Off-Car Shrink Compared With Net Sales Shrink.

<u>Averages</u>					<u>PERCENTAGE</u>						<u>Averages</u>	
Off-Car Weight					Sales Weight							
Class of Cattle	No. of Head	Percent Shrinkage	Loading Weight	Hours En route	Class of Cattle	No. of Head	Percent Shrinkage	Loading Weight (in lbs.)	Hours En route	Hours in Yard Before Sale		
Calves	1466	8.8	400	108	Calves	969	4.3	413	38	52		
Feeder Steers	3543	9.0	838	102	Feeder Heifers	139	3.5	687	36	37		
Slaughter Heifers	206	4.7	877	49	Feeder Steers	726	4.4	811	38	30		
Slaughter Steers	469	7.0	1065	23	Cows	229	6.4	1246	63	27		
Calves *	127	11.9	413	215								

* En route an extra long length of time.

Source: Data obtained for cost of Marketing Study at M.S.C., 1952-53.

cattle, loading weights, hours en route to market, and hours in the yards after arrival and previous to sale. In addition, variations in the shrinkage estimates may occur when numerous factors, which have not been recorded, change in degree or proportions.

C. Factors Causing Shrinkage

From observations of producers and dealers it is believed that many, many factors are responsible for the amount of shrinkage and for the variations in shrinkage.

Factors which have been commonly thought to influence shrinkage are listed below:

1. Length of journey or the number of hours that the animals are en route has long been thought to influence the amount of shrinkage. It is believed that the longer the animals are en route, the greater will be the shrinkage. Furthermore, it is believed that the shrinkage is heavier during the first part of the journey, than it is during the last part. This point is rather well illustrated by use of a table from the study made by Abbenhaus and Penny in 1951. ^{1/} These figures indicate that almost one-half of the total shrinkage takes place within the first one-eighth of the total 200 mile trip. At the end of one-fourth of the distance the steers had completed about two-thirds of their total shrink. After the first one-half of the haul, the shrink was 84.4% of the total shrink. The results indicate that very little shrinkage occurs after the first 100 miles

^{1/} Ibid, p. 7.

Table XI. Percent Shrink For 60 Fat Cattle Between Each Check Weighing During a 200 Mile Truck Haul. (Total Animal Weight Equals 100%).

Weight Classes	No. of Head in Each Class	Average Weight	Miles Traveled Between Weighings				
			0-25	25-50	50-100	100-200	Total %
Group Average	60	1122	1.8	.7	.8	.6	3.9
Under 1000 lbs.	11	954	1.5	.7	.9	.8	3.9
1000-1099 lbs.	10	1056	2.1	.9	.8	.3	4.1
1100-1199 lbs.	24	1139	1.8	.8	.8	.7	4.1
Over 1200 lbs.	15	1263	1.9	.5	.7	.5	3.6

and it takes place at a decreasing rate from then on.

2. The degree of comfort to the animal in the shipment has been considered one of the factors which influences shrinkage. By this is meant the effects of extreme variations in weather conditions, badly crowded cars, and slow, rough train runs. If the weather is extremely hot or cold, the animals are naturally uncomfortable and they will shrink greater than under normal weather conditions. Therefore, cattle tend to shrink more when shipped during extremely hot or cold seasons of the year.

3. The number of, and hours at, feed and rest stops is another factor that is believed to influence shrinkage. If there are feed and rest stops available for the animals to spend some time eating, drinking, and resting, then the shrinkage may be decreased accordingly.

4. Age of the animal is thought to be a factor which influences shrink, since the body weight of younger animals contain a larger percent-

age of water. 1/ When water is lost as shrinkage it constitutes a heavy loss in pounds and consequently a heavy shrinkage results. Older animals, therefore, do not shrink as much as do young calves according to this assumption.

5. Class and breed of animal also are believed to influence shrinkage in the same manner as does the age of the animal. Many people believe that certain classes and certain breeds have a larger percent of body weight made up of water which influences the shrinkage total accordingly.

6. Size of the animal is supposed to influence shrinkage percentages. The larger the animal the more pounds it will shrink, but these pounds are a smaller percent of the larger animals. 2/

7. Progeny or family line may also influence shrinkage according to the individual or heritable, physiological characteristics of each family line. Some families may be gentle and docile, and shrink at a slow rate, while other family lines are flighty and wild which causes a relatively rapid rate of shrinkage when the animal is subjected to the unusual conditions of shipment. This theory was not substantiated by a test run on the significance of difference between lines one and two, and one and four, of the Montana Experiment Station stock.

8. Feed fed before, during and after shipment may influence the extent of shrinkage that occurs in an animal. The amount and type of feed

1/ Snapp, Roscoe R., Beef Cattle, Their Feeding and Management in the Corn Belt States, John Wiley and Sons, Inc., New York, 1950, p. 233.

2/ Abbenhaus and Penny, op. cit., p. 8.

before shipment may influence the rate of shrink, inasmuch as green feeds will be lost as excretory shrinkage rather rapidly, while dry pasture feeding or dry lot feeding before shipment is thought to be associated with a less rapid shrink. The amount and kind of feed en route may influence shrinkage. If adequate good feed is available the shrinkage loss can be decreased more than if inadequate or poor feed is available. While the animals are in the sale yards after shipment they should be allowed sufficient good feed to put on a good fill to restore weight lost, according to the personal opinions of people engaged in the livestock trade.

Even more important than feed, many people believe, is that the water should be adequate and fresh before, during, and after shipment. Cattle with their thirst quenched will eat more dry feed also.

10. The handling of the animals while they are in the marketing process is believed to be very important since excessive running or "cutting" will tire the animals and induce a rapid rate of shrinkage. If cattle are handled roughly there is a resulting loss due to bruising of the animal. Bruising causes a decreased dressed weight. This is essentially considered as a shrinkage loss (tissue) and consequently a slow, easy movement of the stock should be the best policy in order that shrinkage and bruising losses can be held to a minimum.

D. Functional Relationship Between Factors Causing Shrinkage and the Extent of Shrinkage

From the number of factors, which are listed above as believed to influence shrinkage, it is readily seen that there can be many factors that may influence any one shipment of stock. Some of these factors possibly

can be controlled, and others may not. One of the biggest problems is to determine which factors can be controlled or affected sufficiently to effect economic gains. To solve this problem one must seek answers to questions such as the following: Which are the most important factors believed to influence cattle shrinkage, and how important are they? How much variation in the shrinkage is due to these factors? How much variation is due to factors impossible to measure with available data?

Answers to these questions may be approached through the use of statistical analysis employing multiple correlation.

This problem is approached as it is related to the shrinkage of steers sold from the Miles City Branch Experiment Station. The conditions surrounding these particular shipments have been outlined in the previous material. Suffice it to say that these animals were yearling slaughter steers shipped from Miles City to South St. Paul in July for a period of 9 years between 1942 and 1952.

These steers were given one feed and rest stop en route to market, and the conditions of shipment each year were comparable with the exception of the factors which will be considered in the following analysis. These factors as set up in the correlation problem are:

X_1 = pounds of shrinkage of the animals as determined by the difference between loading weights and sales weights.

X_2 = the actual loading weight of the animals in pounds.

X_3 = the number of hours that the animals spent actually on rail en route to the market.

X_4 = the number of hours that the animals spent off-car at feed and rest stops. (Note: All shipments were fed and rested one time only).

X_5 = the number of hours the animals spent in the yards after arrival and previous to sales (refill period).

The regression equation was obtained from the data involved by using deviations from the mean of each factor to obtain the regression coefficients. The regression equation was found to be:

$$X_1 = .6483 + .77545X_2 - .4377X_3 - .02041X_4 - .26131X_5$$

The b values and the regression equation can be interpreted in the following manner: 1/

With a 10 pound (1 unit) increase in the loading weight of the animal (X_2), there is a corresponding .77545 pounds of increase in the pounds of shrink (X_1) while the effects of other factors ($X_{3,4,5}$) are eliminated. With a one hour (one unit) increase in the hours on rail (X_3), there is a decrease of .4377 pounds of shrinkage (X_1), with the effects of the other factors eliminated.

With a one hour increase in the hours at feed and rest stops (X_4), there is a decrease of .02041 pounds of shrinkage, while the effects of $X_{2,3,5}$, eliminated.

With a one hour increase in the number of hours between arrival and sale (X_5), there is a decrease of .26131 pounds of shrinkage, when the effects of the other factors observed, are eliminated.

When all the independent variables are zero (0) the dependent variable

1/ Thus, the b values were:

$$\begin{aligned} b_{12.345} &= .77545 \\ b_{13.245} &= .43770 \\ b_{14.235} &= .02041 \\ b_{15.234} &= .26131 \end{aligned}$$

(X_1), pounds of shrinkage, has a value of .6483 [(a) value].

By reference to the regression coefficients the corrected multiple correlation coefficient is obtained with a value of $R_{1.2345} = .54$. This measures the degree of association between X_1 and $X_{2,3,4,5}$. There is a fair degree of correlation between the number of pounds of shrinkage and the loading weight, hours on rail, hours at feed and rest stops, and hours in yards between arrival and sales. The corrected coefficient of determination is $R^2_{1.2345} = .2919$. This is the percentage determination and it indicates that, according to the data used, 29.2% of the variation in shrinkage (pounds) is due to variations in loading weight, hours on rail, hours at feed and rest stops, and hours between arrival and sales. The correlation coefficient is significant at the 99% level, which means that the chances are less than 1 in a hundred that a correlation coefficient as high as .54 is due to random error of sampling.

These statistical measures all substantiate the common beliefs and hypotheses that have been projected in relation to shrinkage. One exception to this substantiation is the relationship between pounds of shrinkage and hours on the rail.

Many people have observed shipments which shrink more the further they are shipped. 1/ According to the regression coefficient obtained in the previous analysis, the further the animal is shipped the less the shrinkage will be. Therefore, the common belief is not substantiated by the statis-

1/ The regression equation and correlation analysis on page 39 of this study is an illustration of this point.

tical analysis on this point. It might reasonably be assumed in view of the strong belief in the causal relationship of time en route to shrinkage that there are a number of other factors interrelated with time en route, which are not tested or recorded in this correlation analysis. This inter-serial relationship might well be so important that the time relationship is not revealed in a study of only a small portion of the variables associated with shrink.

The relative importance of the four factors in relation to each other is determined by the use of partial correlation coefficients. 1/ According to these, weight of the animal (X_2) and hours on rail (X_3) are the only two that are significant and they are significant at the 99% level. The other two factors, hours at feed and rest stops, and hours between arrival and sale, did not prove to be significant. This means that the values of their respective partial correlation coefficient, $r_{14.235} = -.212$ and $r_{15.234} = -.196$, could be this large due to chance alone and therefore, cannot be considered to be significant.

The total explained variation is only 29.2% and consequently it may be stated that there must be numerous factors which have not been considered which could explain the remaining 70.8% of the variation in shrinkage. Some of the factors which have not been considered in the problem are: comfort of the animals - which includes extreme temperature condi-

1/ The partial correlation coefficients are: $r_{12.345} = +.373$
 $r_{13.245} = -.362$
 $r_{14.235} = -.212$
 $r_{15.234} = -.196$

tions, rough train handling, and poorly bedded and sanded cars, age of the animal in relation to nervousness and moisture content of the stomach, class and breed of animal, feed and water before, during and after shipment, progeny of the cattle, and finally, handling of the animals during the shipping process.

Any one of these factors may not be too important, but if all of them were considered it is probable that a large portion of the unexplained variation could be explained.

PART III.

Economic Implications of Shrinkage Occurring
During the Marketing Process.A. Theoretical Framework for Appraisal of Economic Significance.

To estimate from an economic viewpoint the importance of live-
stock shrink to society and to people directly concerned with the market-
ing process, the shrinkage problem will be analyzed through the use of
theoretical tools and criteria.

The analytical economic framework as set up in Section 1, of Part III
and Section 2 of Part III, is concerned with combining the empirical in-
formation obtained with these economic criteria or framework.

1. Theoretical Assumptions. To approach any problem in an economic
setting it is necessary to make certain assumptions with respect to the
problem at hand. Some of the assumptions which are deemed necessary to
analyze the problem, follows:

(a) It is assumed that it is desirable to prevent any net loss to
society. Consequently the function of welfare economics should be con-
sidered. Welfare is defined by using a definition of a welfare indicator
which increases and decreases with welfare--welfare is that which varies
with the indicator. The indicator is defined as follows: Welfare in-
creases whenever one or more individuals become more satisfied without any
other individuals becoming less satisfied. 1/

(b) The assumption is made that the individual livestock producer

1/ Reder, Melvin Warren, Studies in the Theory of Welfare Economics,
Columbia University Press, New York, 1951, pp. 14, 15.

is facing a perfectly elastic demand curve. This perfect elasticity of demand is reflected by a zero change in price with any amount of change in quantity up to infinity. This is to say that an individual producer may place as many animals or as large an animal on the market as he can, and he will receive the same price for each unit (assuming homogeneity of units). The situation of a perfectly elastic demand curve with two supply levels on the market is illustrated in figure 2.

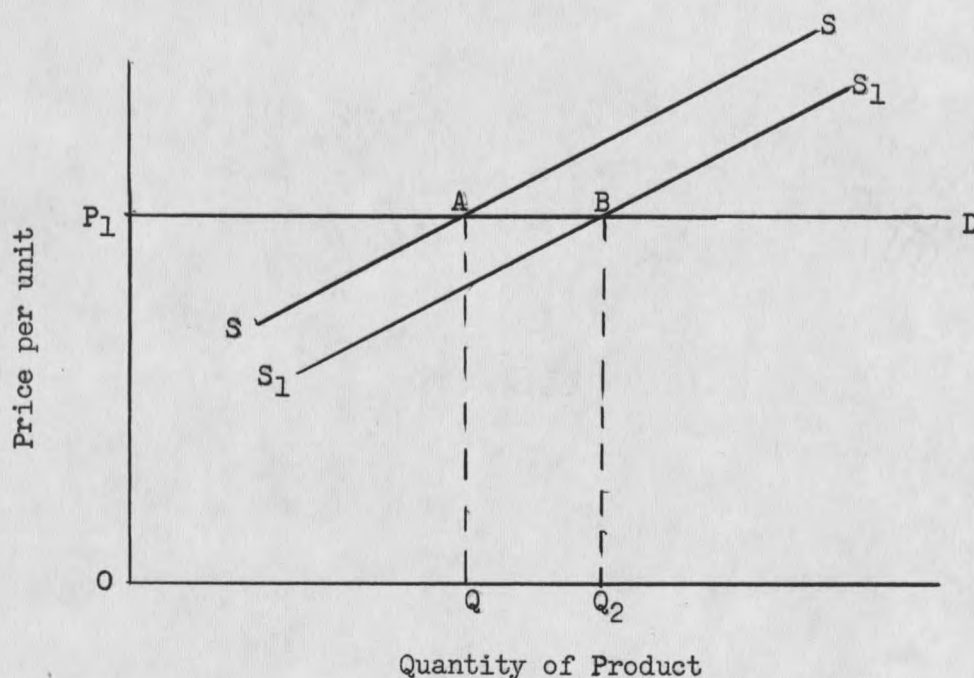


Figure 2. A Firm Facing a Purely Competitive Demand Curve, Places Two Quantities on the Market.

The horizontal line D is the demand curve that the individual firm faces, and point A on curve SS, shows the amount of product that is originally placed on the market. Point B on supply curve S_1S_1 shows a new and greater quantity of the product placed on the market by the firm with no change in price occurring. With the supply at A, the firm will

receive $(P_1)(Q_1)$ as a total revenue. With the supply increased to point B, the total revenue becomes $(P_1)(Q_2)$, which is an increase in total revenue of $(Q_2 - Q_1)$ times P_1 .

(c) It is assumed that ranchers, as entrepreneurs, are striving to maximize net returns. The theory of the firm is a general set of principles relating to factors of production which are employed in economic units capable of producing economic goods. It serves as a tool with which the firm may be reduced to its component parts. 1/

One assumption, basic to the theory of the firm is that the entrepreneur is striving for maximum profits. The theory is as widely accepted in the attempt to maximize profits as the law of supply and demand in determining price. 2/

The equilibrium position of the firm depends upon the slope of the market supply and demand curves and the price of inputs and outputs. Enterprise combination, size of the firm, and optimum resource use are all directly dependent on the combination of these factors.

(d) The next assumption is based on the conclusion that an optimum solution to costs and returns takes place where $M.C. = M.R.$ under competitive conditions.

Under pure competition as has been assumed, the price per unit will equal the marginal revenue and where the $M.C. = M.R.$ there is an optimum

1/ Quenemoen, M.E., Economic Aspects of Water Spreader Developments on Southeastern Montana Ranches, (Montana: Experiment Station, December, 1952), p. 17.

2/ Heady, Earl O., "Economic Models in Farm Production Economics Research", Journal of Farm Economics, XXX (May, 1948), p. 202.

condition of production. This point is shown in figure 3 at Point A, where M.C. (marginal cost) equals M.R. (price, or marginal revenue). Production will increase as long as the cost of the additional unit is less than the returns obtained from the additional unit. When these two become equal, then the increase in production will stop since beyond this point the additional cost will be greater than the added revenue.

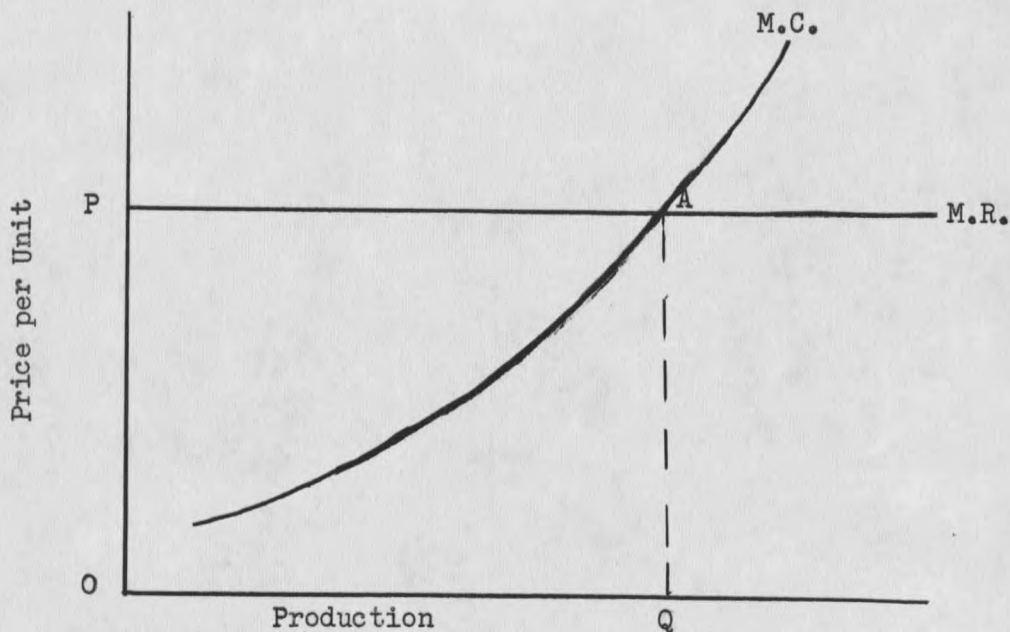


Figure 3. A Firm Facing a Perfectly Elastic Demand Curve Seeks an Optimum.

In observing the previous assumptions it may be seen that two of them would be in conflict with each other if the market were under conditions of monopoly rather than in conditions of pure competition surrounding agricultural commodities.

Possible conflicts in a monopoly may come between profit maximization and national welfare maximization.

For a monopolist, the sales schedule of the firm is identical with the demand schedule for the product of the industry, since buyers can obtain the product only from this firm. Thus, in figure 4 the Average Revenue curve represents both the total demand for the product and the sales schedule for the firm. For this average-revenue curve there is an appropriate marginal-revenue curve. The firm will operate at the point of equality of marginal revenue and marginal cost and will set the price at which this quantity can be sold (P_1 in figure 4, if it is seeking to maximize profits.)^{1/}

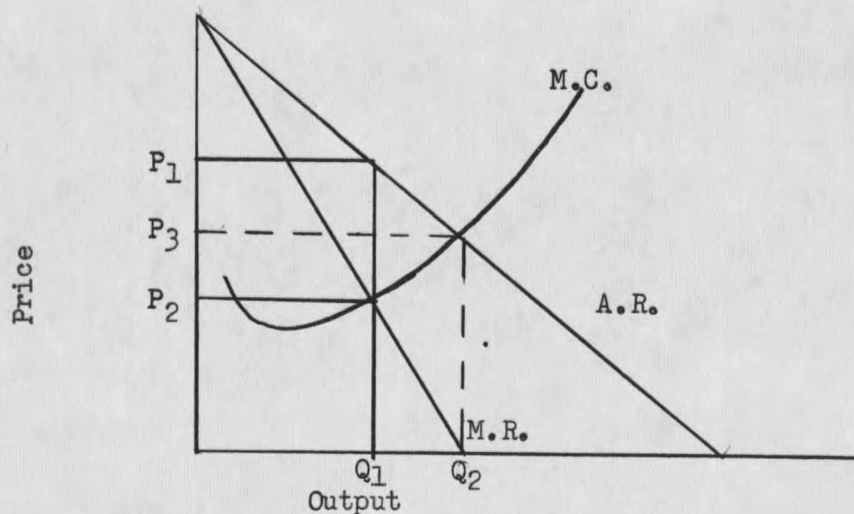


Figure 4. A Firm Facing Monopolistic Market Conditions.

With a monopoly the firm will produce quantity Q_1 but will charge P_1 rather than P_2 . If this firm were seeking to maximize national welfare it would produce either quantity Q_1 at price P_2 , or it would produce quantity Q_2 at price P_3 . From this, it is seen that the monopolist is not

^{1/} Due, John F., *Intermediate Economic Analysis*, (Chicago, Illinois, Richard D. Irwin, 1951), p. 256.

using all available resources, (or greater quantity would be produced), or he is charging a price which is higher than the socially relevant price (P_2), for his product.

Considering production (as in agriculture) carried out under market conditions of pure competition, the following illustration (figure 5) is useful.

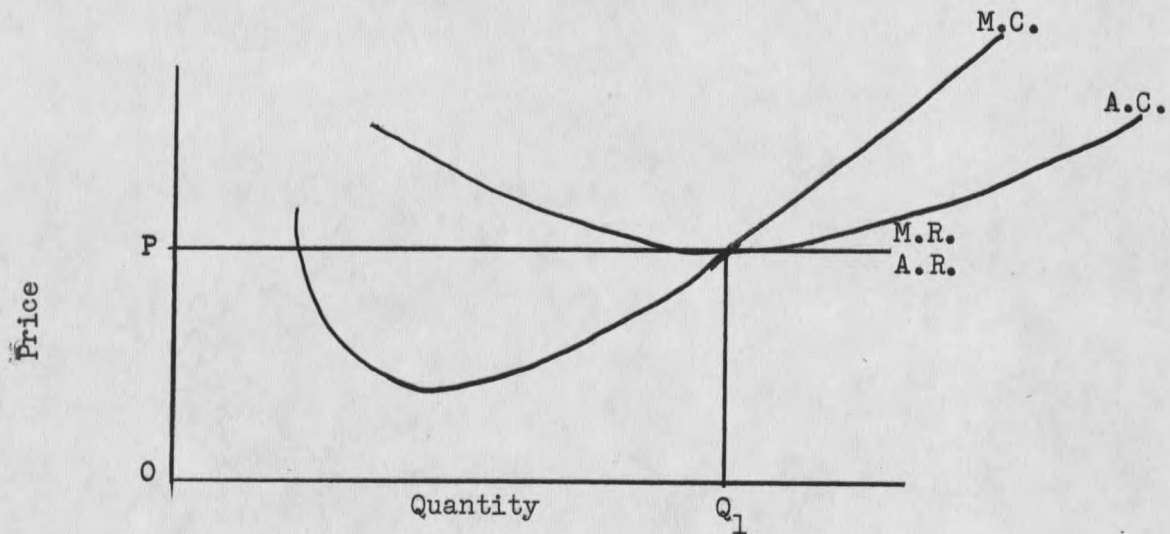


Figure 5. A Typical Demand and Cost Function in Agriculture.

In figure 5 Marginal Revenue equals Average Revenue since the same price will be obtained for each additional unit. The firm will produce where Marginal Cost equals Marginal Revenue as was the case in the monopolistic situation. The individual producer cannot affect the market by his sales under competitive conditions. The other difficulty found in a monopoly is also eliminated under competitive conditions since more firms will come into the industry, when resources are available and prices are favorable, to use up excess resources.

2. Economic Analysis of Empirical Evidence.

(a) Welfare is increased as total satisfactions are increased (See Assumption (a), page 53). If an individual producer or firm can increase his satisfactions without decreasing any other person's satisfactions, then welfare is increased. Under market conditions that are in effect at the present time, a firm may absorb a loss through a shrinkage or it may undergo a cost of reducing shrinkage as an alternative. The direction of the firm's action is determined by the relative prices of beef and the prices of factors that may be used to reduce shrink.

Illustrated in figure 6 is an iso-cost curve I_1 at a given level of income. Pounds of beef lost due to shrinkage is plotted on the vertical axis, and the index of factors which constitute costs of shrinkage reductions on the horizontal axis. Without considering the price relationships the firm may take a position any place along the curve. It may absorb a shrinkage loss of X_1 and a resource cost of Y_1 or it may absorb a shrinkage loss of X_2 and an index of shrinkage reduction of Y_2 , or any other combination of the two on the curve. Any position on the curve will give equal satisfactions.

The factors that determine the position of the firm on the iso-outlay curve are the relative prices of beef lost and prices of factors which make up costs of reducing shrinkage. In figure 6 the equilibrium position is shown at Point (a) where the price line (PP) is tangent to the iso-cost curve. At this point the ratio of the price of beef to price of cost factors is equal to the marginal rate at which loss through shrinkage will

substitute for expenses incurred to reduce shrink. 1/ Any other point on the iso-cost curve is not a true equilibrium position if a firm is acting in a rational manner with respect to the price relationships in effect.

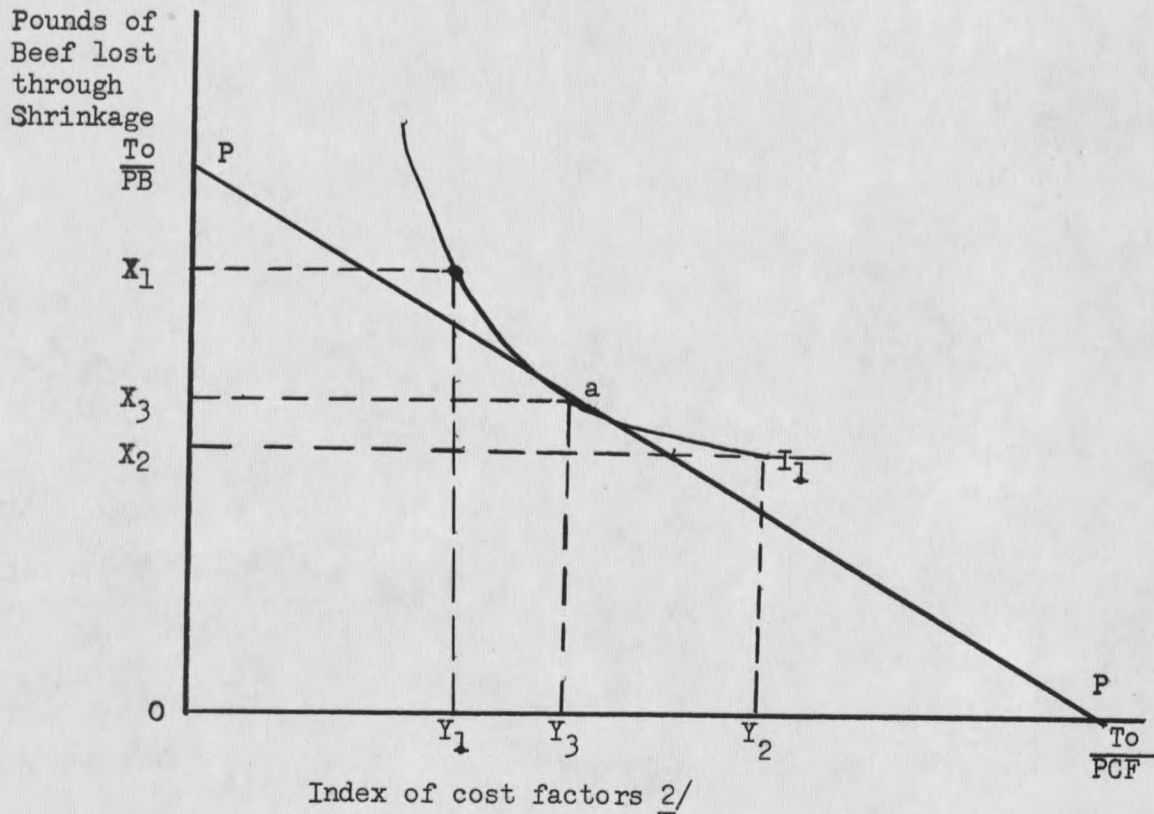


Figure 6. Equilibrium Position of a Firm Acting Rationally and Irrationally With Respect to Welfare Maximization.

$$\frac{1/}{P_c} \frac{P_b}{P_c} = \text{M.R.S.} \frac{(c)}{(b)}$$

where: P_b = price of beef

P_c = price of cost factors

M.R.S. = marginal rate of substitution

(c) = costs of reducing shrink

(b) = loss due to shrinkage

2/ The index of factors is made up of the number of units of labor, feed, and other extras which constitute means of reducing shrinkage.

When the firm is operating at point (a) in figure 6, the greatest possible net income is obtained and the welfare of society is also maximized with respect to the individuals income. It may be, that due to poor management, or lack of knowledge with respect to the equilibrium position, the individual producer or firm will not reach the equilibrium position at point (a). At the equilibrium point, X_3 would be absorbed as a loss through shrinkage, and Y_3 would be spent to reduce shrink. A producer may unknowingly be located any place on I_1 outside of point (a), while it is desirable from his own and society's viewpoint to be operating at point (a) where satisfactions are greater. 1/ The nearer the optimum point that a firm operates then the greater the income, and through more income satisfactions can be increased.

The assumption of welfare economics seems to be a rather valuable tool for determining whether or not shrinkage should be controlled. If the welfare or total satisfactions can be increased by reducing shrinkage, then this logically should be the course to follow. The difficulty in this matter lies in the problem involved in determining just when during the marketing process does excretory shrinkage occur, and when does tissue shrinkage occur. It is also very difficult to determine how much of the shrinkage is excretory and how much of it is tissue shrink. This differentiation is essential as social loss is a result of tissue shrink. With the present method of handling and weighing of animals in the market, it

1/ The firm may even operate at point $\frac{To}{Pb}$, where To equals total outlay and Pb equals the price of beef, or it may operate at point $\frac{To}{PCF}$, where To equals total outlay and PCF equals the price of cost factors.

seems that there is no way, outside of a closely controlled study, of determining when and how much of each type A shrinkage occurs. Even with a controlled study the two types of shrinkage may occur simultaneously which would make it next to impossible or at least economically unfeasible to determine when, and how much of, each of the shrinkage takes place.

There are two major ways that the shrinkage could possibly occur. One of these would be where excretory and tissue shrinkage begin at practically the same time and occur simultaneously throughout the marketing of the animal. If this were the predominant method, then it would be so difficult to differentiate between the two as to be an impracticality. The other way that the shrinkages may occur is where excretory shrinkage occurs, for example,, the first one-third of the period en route to market, then for the next one-third of the period both excretory and tissue shrinkage occur, and the last one-third of the time consists of tissue shrinkage occurring individually.

Unless some practical method for determining when each of the two types of shrinkage occurs and a method of ascertaining the extent of each is developed, it would be impossible to determine precise measures of society's loss due to a loss in weight of the animal. If the amount of society's loss, due to tissue shrink could be designated then some economic tools could be used to determine an optimum control range. Within this range, factors affecting tissue shrink could be maintained. Until the time comes that these measuring methods can be incorporated into the marketing process, it seems that the best way would be to assume that by controlling shrinkage in general at an optimum point, tissue shrinkage

would also be decreased. Consequently, total satisfactions and income would increase. An increase in the welfare of society would result.

(b) As has been stated, under monopolistic conditions, the price may vary according to the amount of the product placed on the market by the monopoly firm. This is not the case under conditions of pure competition for an individual firm. When pure competition is in effect, the amount of any one good that a firm or producer places on the market will not have any effect upon the price he will receive. The firm under pure competition faces a perfectly elastic demand curve. This situation seems to exist in a good deal of the agricultural commodities. There are so many producers who produce the same good, but in such small quantities in relation to the total supply, that they do not influence price by their production. If a rancher or dealer can place more product on the market he will receive a greater return. Therefore, if a producer or dealer can decrease the amount of shrinkage that takes place in the livestock in the marketing process he will have more pounds of animal to place on the market and receive a greater total return.

The perfectly elastic demand for beef, faced by the individual producer, is designated in figure 7 by D, which has been assumed to be at a level of twenty cents per pound. If a producer with a supply curve demonstrated by SS places a 1000 lb. animal on the market, he will receive \$.20 per pound, or a total revenue of \$200.00 (\$.20 times 1000 lbs.) for the animal. If it is assumed that the shrinkage is controlled in such a manner by the firm, as to increase the total weight of the animal to 1050 lbs. (S_1S_1) then the total revenue would be \$210.00 (\$.20)(1050) for the animal.

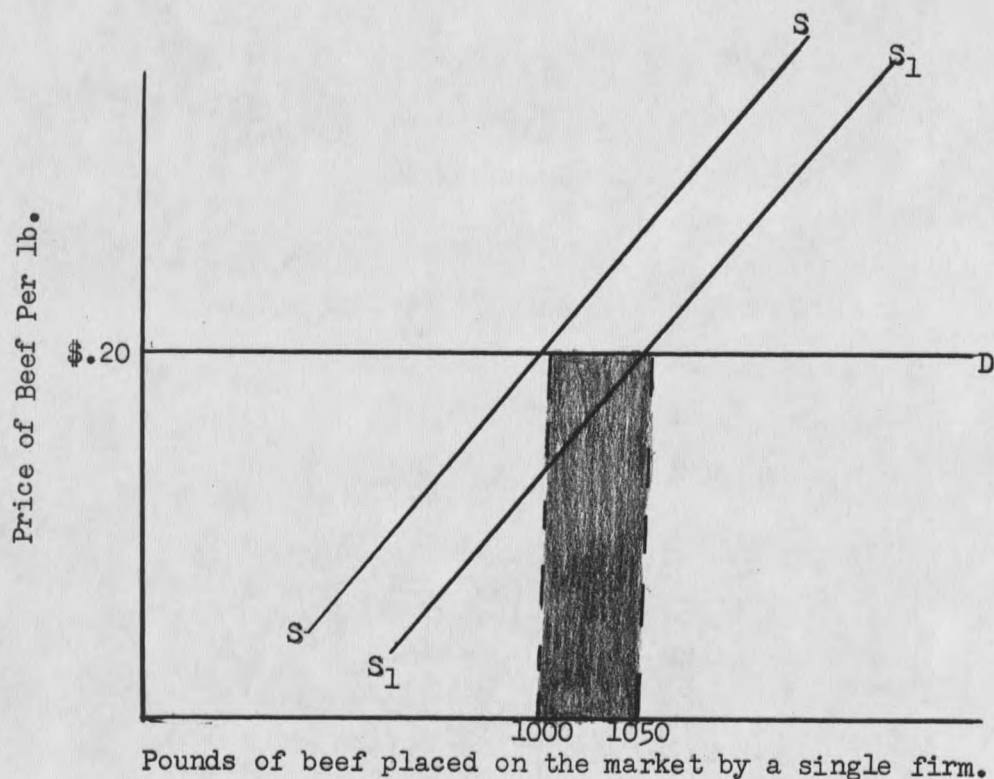


Figure 7. A Beef Producing Firm Facing a Perfectly Elastic Demand for Beef, Places Two Quantities on the Market at a Price of 20¢ per lb.

The difference of \$10.00, the shaded portion of figure 7, is an increased return to the producer or firm as compensation for a reduction in the shrink. This reduction in shrinkage may be attained by controlling the factors which influence shrinkage as has been suggested in Part II of this study.

The assumption, of equal prices to be paid for different quantities, is only applicable when the product is homogenous in every unit. If the product is not homogenous, there would technically be a different product placed on the market and a resulting shift of prices would occur. A different product would be in evidence if an excessive shrinkage or an ex-

cessive fill took place in cattle placed on the market. A buyer is actually paying his price according to the dressing percentage expected on an animal or the weight of the dressed carcass. Therefore, the price offered will vary according to the amount of fill the buyer judges the animal to have.

If an animal is well filled a lower price will be bid. If an animal is well shrunk out, then the buyer will bid a higher price and still be obtaining the same dressed weight. A differentiation of prices paid is shown in figure 8, where various "products" are placed on the market, the variation being caused by the amount of fill in the animals. With the use of hypothetical figures various returns to the firm (seller) can be shown.

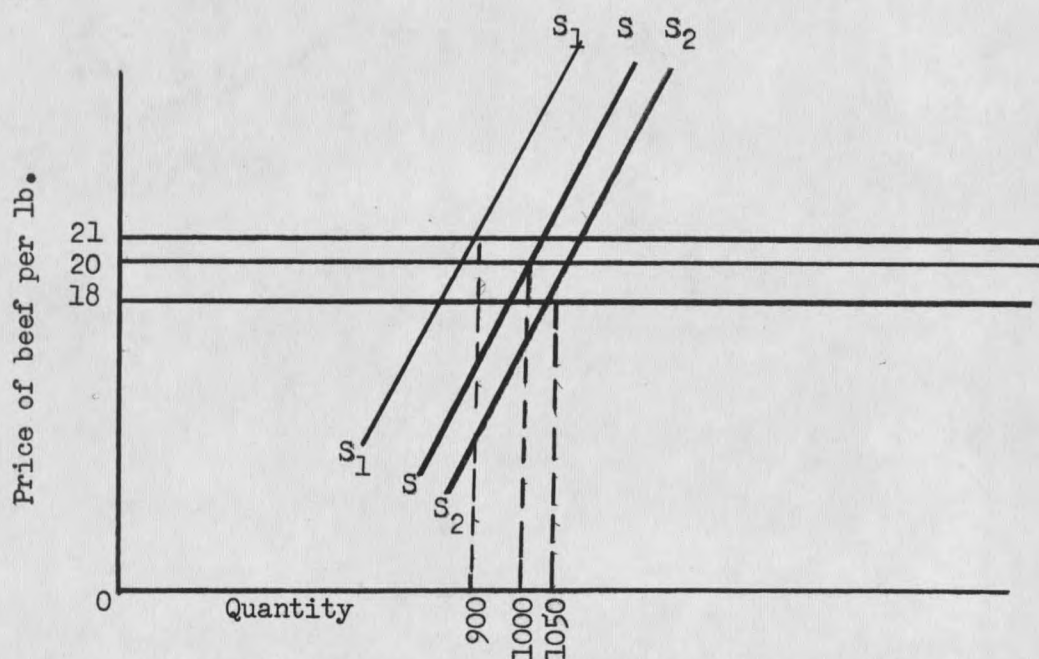


Figure 8. Price-Supply Relationship for an Individual Firm Placing Animals on the Market Under Three Shrinkage Conditions.

If an animal with a normal appearance is placed on the market, the price may be bid on the \$.20 per pound basis. If the animal weighs 1000 pounds when in normal condition the seller would receive \$200.00 (\$.20) (1000) for the animal. If the seller tried to get a greater total return from his animal by increasing the selling weight by putting a good fill on the animal, then the price may be quoted at \$.18 per pound. If the animal has taken on a fill of 50 pounds over the normal weight of 1000 pounds, the return to the seller would be \$189.00 (\$.18) (1050). This would mean a loss of \$11.00 to the seller due to an excessive fill on the animal. When an animal is shrunk out excessively, 10 percent below the normal weight for example, then a higher price of, say, \$.21 can be paid by the purchaser. With a 10 percent shrink, the normal 1000 lb. animal would weigh 900 lbs, and the returns to the seller would be \$189.00 (\$.21)(900). This would also mean a loss of \$11.00 to the seller. As is shown in this case, an excessive shrink or an excessive fill may both be detrimental to the seller. This is in view of the fact that buyers will offer different prices when different amounts of shrink or fill are in evidence.

A seller must be very careful then, in the amount of shrinkage or the amount of fill that takes place. Excessive shrinkage should not be allowed if the price and weight relationship is comparable to that in the above example. Although a shrinkage reduction is recommended, a refill beyond the "normal" fill of an animal should not be encouraged under these conditions.

(c) The theory of the firm assumes that each individual or firm is

attempting to maximize returns. The two factors responsible for total returns to a rancher from sale of cattle are price paid per pound and the number of pounds. Under conditions of pure competition, as has been demonstrated price will be exactly the same regardless of the quantity of the same commodity that the firm places on the market. This leaves pounds of animal to be controlled or varied by the producer as a means of maximizing return. Under these conditions the number of pounds should be maximized to maximize total returns. If the producer or dealer can reduce shrinkage of the animals as much as possible, this will be an aid to increasing the number of pounds of animal that is placed on the market (assuming identical products before and after shrinkage, which is true if an excessive shrinkage or fill does not occur). Consequently this is seen to be one of the methods available to aid in maximizing total returns.

Available methods for the reduction of shrinkage according to the preceding empirical analysis are: to increase the hours at feed and rest stops and to increase the hours for a refill period in the yards after arrival and before sale. If the hours at feed and rest stops are increased one hour, the animals will gain back .02 pounds of weight on the average based on a partial analysis. An increase of ten hours, therefore, would result in an increase of .2 pounds.

In other circumstances the regain at feed and rest stops may be greater. The animals may shrink steadily until a feed and rest stop is used. Then the shrink may decrease while at the feed and rest stop, but will increase again as soon as the animals are reloaded and en route once again. (See figure 9). This cycle may be repeated again for as many

feed and rest stops as are used.

Shrinkage may be replaced at a fairly rapid rate at first. ^{1/} Regain may be as rapid as the corresponding loss for a short period of time. As the weight becomes more difficult to regain the spread becomes wider and wider between shrink and regain, and a longer time is necessary to regain the weight lost during the last part of the shipment. This may occur even with equal decreases in shrinkage during subsequent feed and rest stops. A feed and rest stop at any time during the shipment will, nevertheless, be a benefit or an aid in shrinkage reduction, and increase the pounds placed on the market. (see figure 9)

To increase the number of pounds on the market, a firm may also increase the number of hours in the yards previous to sale. For each additional hour in the yards after arrival and before sale, the animals shipped from Miles City Station increased their weight by .26 pounds on the average. This means that for every additional day spent in the yards before sale, an animal weighing 956 pounds will replace 6.24 pounds, until the animal is back near the loading weight. (Animals observed were not held in the yards for more than 5 or 6 days, therefore the rate of regain should not be projected beyond this time).

Increasing total weight will give the individual a maximum total return but does not consider the cost of increasing weight by decreasing shrinkage. To introduce costs into the analysis, assumption (d) is considered.

^{1/} See pages 71 and 72 of this study.

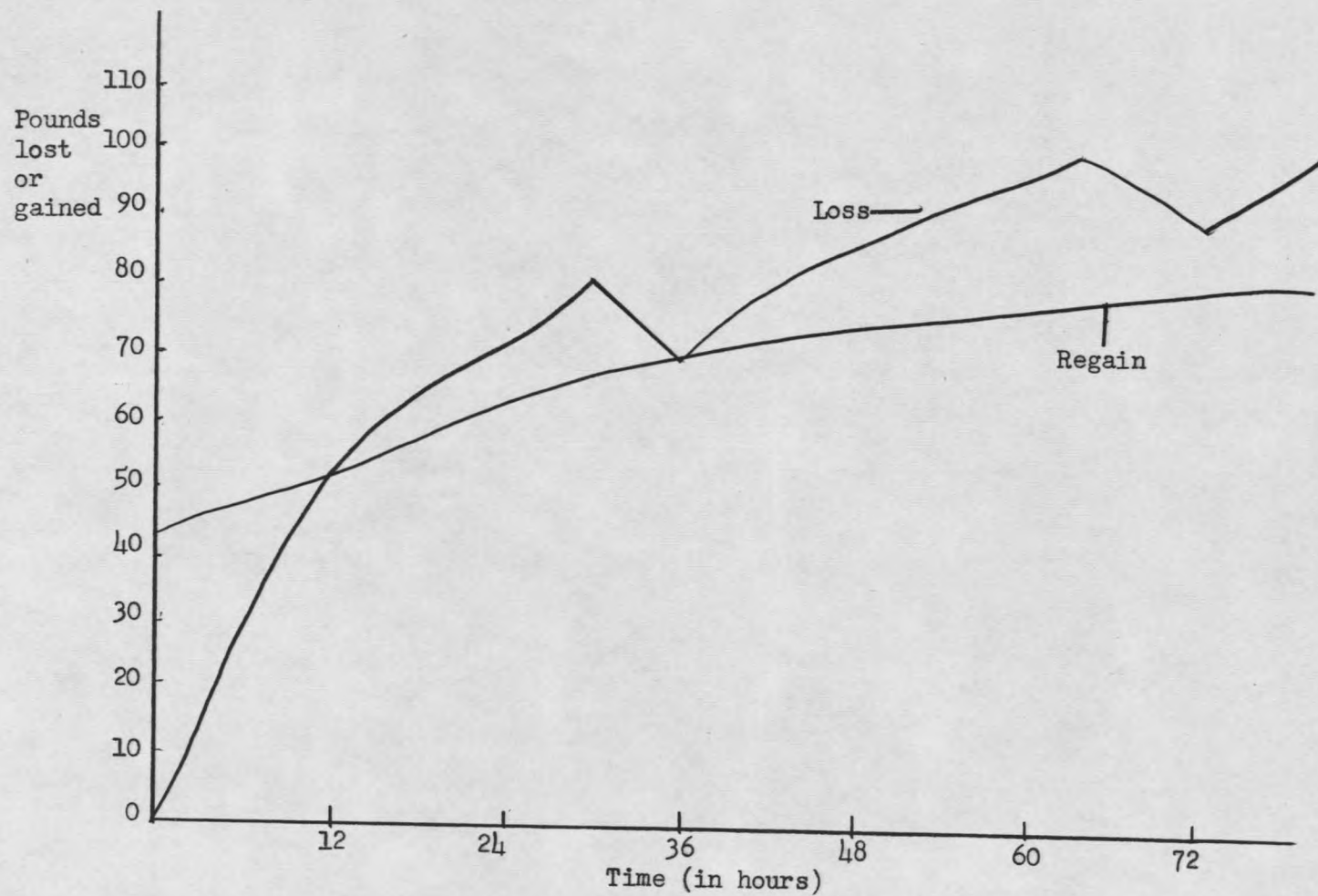


Figure 9. Pounds of Beef Lost in One Time Period and Regained in Another.

(d) Optimum solution of cost and returns takes place where marginal cost equals marginal revenue under competitive conditions. If the returns for the last unit placed on the market is greater than the cost of placing that unit on the market, the optimum is not attained. More units may be placed on the market even though the cost of placing that unit on the market is greater than the previous unit costs. If weight can be increased the increase should be striven for, unless marginal cost is equal to or greater than marginal revenue. To increase the weight of an animal after shrinkage, two of the possibilities available are; (1) to increase the number of hours at feed and rest stops and (2) to increase the number of hours in the yards before the sale. These increases can take place only with additional costs.

The average cost per hour at feed and rest stops is approximately seven cents per head. ^{1/} By increasing the time at feed and rest stops by one hour the weight is increased .02 pounds. With a hypothetical value of 20 cents per pound a 956 pound animal will yield a return of one-half cent. Consequently, the marginal cost per hour equals seven cents while the marginal revenue equals one-half cent; therefore, unless other factors are considered such as "humaneness" and health of the animals it would not be economical to keep them for additional time at feed and rest stops. This is in the specific case of Experiment Station slaughter steers, and it will probably vary a good deal from this in other cases, especially where the animals are not so highly finished, and assuming no

^{1/} Miscellaneous data from Montana Branch Experiment Station, Havre, Montana, 1946-1952.

change in price of animals resulting from shrink or fill.

If the hours at the yards after arrival and previous to sale are increased as a means of maximizing returns, the optimum is determined by the marginal cost as well as returns. The average cost for feeding an animal in the yards equals $2\frac{1}{2}$ cents per hour. ^{1/} The returns per animal for one hour equals an additional .26 pounds multiplied by a hypothetical 20 cents which is equal to 5.2 cents. The marginal revenue equals 5.2 cents while the marginal cost equals $2\frac{1}{2}$ cents. Therefore, it is economical for those people concerned to keep their animals in the yards until the animals have refilled enough to have a normal appearance with the above relationships in effect.

Other cases may be illustrated where the marginal revenue is even greater for each hour in the yards, than was found in the Experiment Station slaughter steers. Another example may be observed in Table XII. In this case the marginal cost would be equal to 2 cents per hour whereas the marginal revenue would be equal to $(.74)(\$.20)$ 15 cents per hour (59.2 divided by 80 equals .74). There is thus a difference of 13 cents per hour between marginal cost and marginal revenue. Therefore, it would be economical to feed in the yards previous to sale until the time came that the costs increased due to feed scarcity or increased demand; or until higher labor and handling costs were effective. The rate of refill for various time periods is obtained by dividing the data in Table XII into 3

^{1/} Miscellaneous data obtained from auction markets in Montana, see Appendix Table XIII.

Table XIII. Shrinkage and Refill of Feeder Cattle in Montana

Hours En route	Loading Weight	Pounds Shrink En route	Pounds Gained in Yards	Pounds Shrink After Refill in Yards	Hours Allowed For Refill in Yards	No. Head
48	667	53.4	69.4	+16.0	48	153
96	723	55.0	57.2	+ 2.2	48	83
72	798	60.7	42.8	17.9	48	102
96	793	53.9	38.0	15.9	48	86
48	705	50.8	50.8	0.0	72	33
72	724	41.3	34.1	7.6	72	53
72	757	47.7	56.0	+ 8.3	72	48
72	767	66.0	69.1	+ 3.1	72	140
72	759	69.1	61.5	7.6	72	67
108	884	83.1	73.4	9.7	108	185
96	667	68.0	61.8	6.2	120	74
48	685	97.3	86.3	11.0	144	39
Ave.75	744	62.2	59.2	3.9	80	88.6

Source: Data obtained for the Cost of Marketing study, M.S.C., 1952-53.

groups---those refilled for 48, 72 and 100 and over hours. The rate of gain per hour of refill was as follows:

48 hr. refill = 1.08# per hour
 72 hr. refill = .75# per hour
 Ave. 124 hr. refill = .59# per hour

If the marginal revenue decreased relative to the marginal costs, because of lower beef prices or a decrease in the rate of gain, then it would not be advisable to feed in the yards after marginal costs exceeds marginal revenue.

The optimum condition of marginal costs and marginal revenue may also be illustrated in graphic form as in figure 10.

The cost of regaining each pound increases because it takes more time, feed, labor, etc., to replace the pounds lost through tissue shrink or

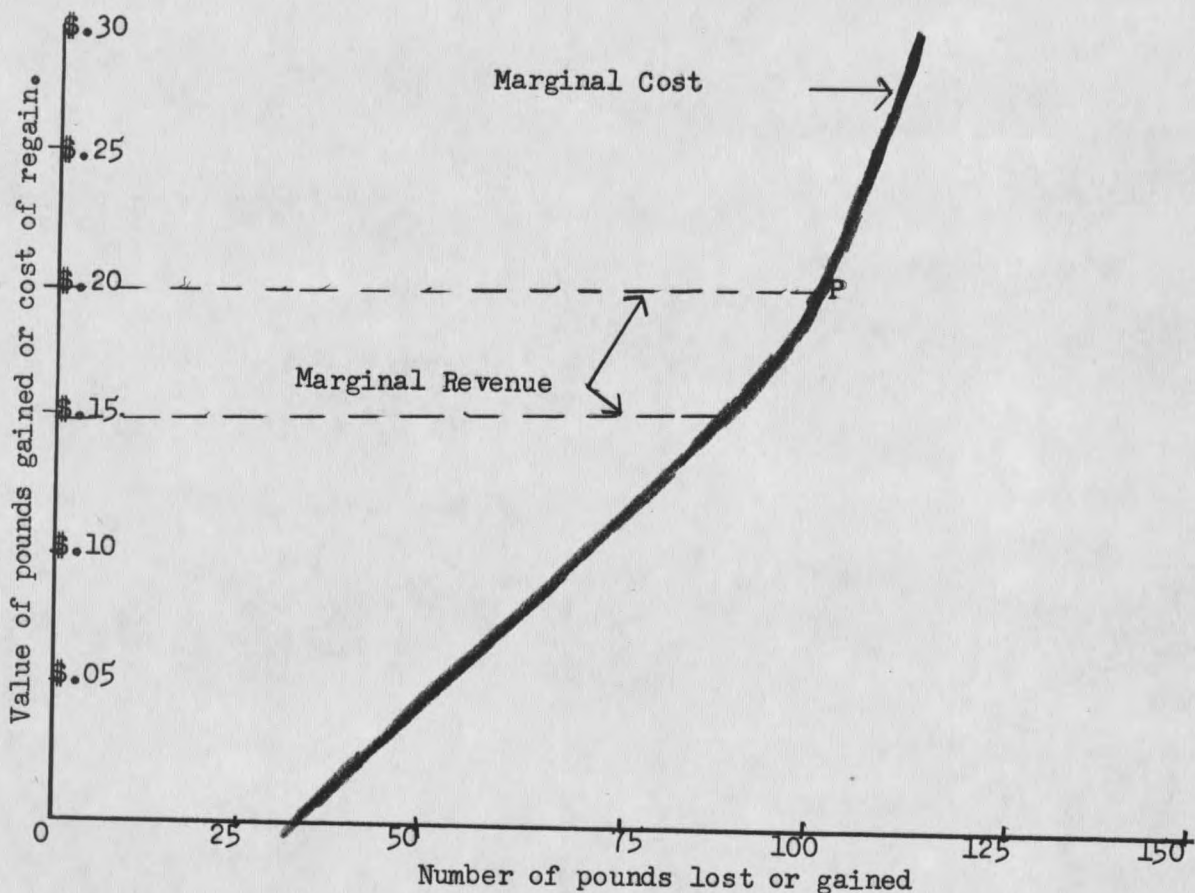


Figure 10. An Optimum Position is Sought by a Firm Where Marginal Cost Equals Marginal Revenue. 1/

even more to replace the last pounds lost through excretory shrink, than it does to replace the first weight lost through stomach loss. 2/ Therefore, the marginal cost curve has a curvilinear function and is increasing at an increasing rate. This makes the two curves meet at point P, (when

1/ Note: The slope of the marginal cost curve is determined by the prices of cost factors as related to length of time needed for each additional pound of regain, see page 69 of this study.

2/ See figure-12 page 75.

beef is 20 cents per pound) where the marginal cost becomes equal to marginal revenue---added cost equals 20 cents; added revenue equals 20 cents. At this point, an optimum is reached and it would be uneconomical to go beyond this point as the marginal cost exceeds the marginal revenue. It would also be uneconomical to stop before point P is attained because the added revenue is greater than the added cost in that area. This applies to any other intersection of marginal cost and marginal revenue depending on prices in effect.

The pounds of loss incurred through shrinkage in a time period, and also the pounds related to the cost of regaining weight may be shown diagrammatically as in figures 11 and 12.

Figure 11 shows the pounds of loss on the vertical scale, and the time in hours on the horizontal scale. Line D represents the amount of shrinkage that occurs as time en route increases. Shrinkage is very heavy for the first two time periods, and after that it increases but at a rapidly decreasing rate. After four time periods have past, the shrinkage does not increase very much.

In figure 12 the pounds of regain (comparable to those pounds lost in figure 11), are plotted on the vertical axis against the cost of regaining weight in dollars. The cost of replacing the first weight lost is very small until about 42 pounds have been regained. The cost increases at an increasing rate as the last pounds lost are more difficult to regain than the earlier part of the shrink. This may be due to the possibility of the last part of the shrinkage consisting of tissue shrink while the first shrink was of an excretory nature.

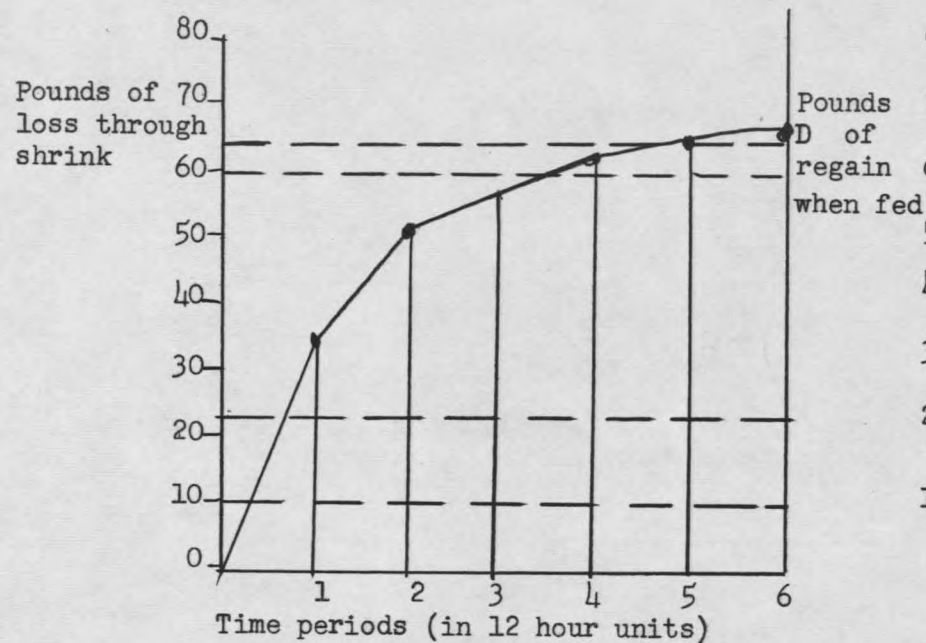


Figure 11. Pounds of Beef Lost Through Shrinkage in Several Time Periods. 1/

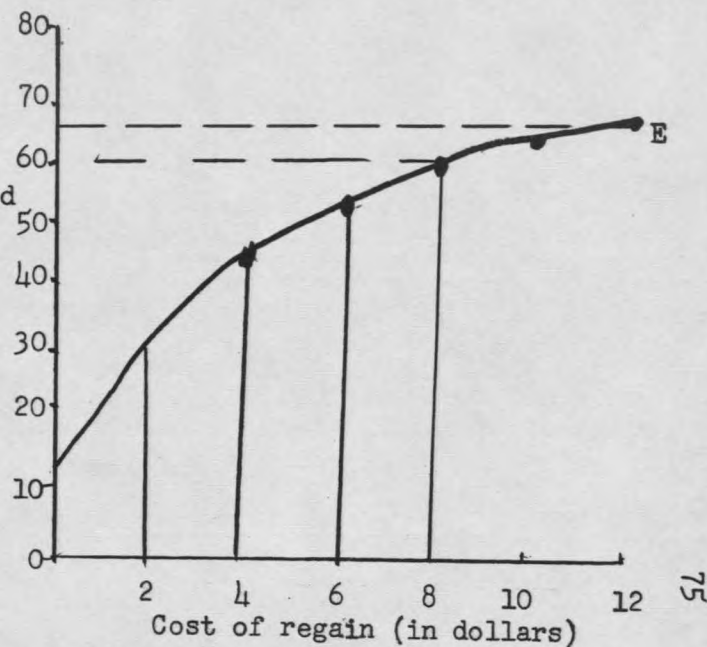


Figure 12. Pounds of Beef Regained as Compared to the Cost of Regain. 2/

1/ See Abbenhaus, Gerald R., and Penney, Roland C., Shrink Characteristics of Fat Cattle Transported by Truck, Chicago Union Stock Yards and Transit Company, Chicago, Illinois, 1951.

2/ See Table XII of this study.

From the foregoing illustrations on equality of marginal cost and marginal revenue, the optimum has been demonstrated in several ways. Nevertheless, the optimum is always found at the same point and that is where the added costs of reducing shrinkage are equal to the added revenue from reducing shrinkage.

B. Rational Marketing Behaviour.

A producer has the difficult task of determining how to sell his stock in attempting to attain the goal of a maximization of net income as has been set up in the "Theory of the Firm". What type of a sales channel should he choose as a market outlet for his cattle? As most of the producers and dealers realize, there are many alternative markets which can be used to sell stock. These markets include central markets, auction markets, and direct sales to purchaser. The producer, in order to maximize profits, will attempt to act rationally and sell through the channel where the greatest net returns can be obtained.

1. Budget Analysis. A rancher may use a set of alternative budgets to aid in determining which method of sale is most profitable. These budgets are useful in setting up and checking possible production and sales methods. Disappointment and financial loss can be avoided by first testing future plans by the budgeting method rather than by actual operation. It is much cheaper to make mistakes on paper than in practice.

In applying the budget-method to a particular rancher who is troubled by the dilemma of choosing the correct method of selling his cattle, a hypothetical Montana rancher who is producing grade Hereford cattle may be considered. This particular rancher has the three methods of sale avail-

able to him; central market, auction market, and direct sale. Some of the circumstances surrounding the possible production and sales procedures are outlined below.

The rancher has an economic unit of 125 breeding cows, which graze on typical Montana range. The unit is operated on a cow and calf basis. The calves are born in the spring of the year, generally near the end of March. All of the stock are run on the range land during the summer and in the fall of the year the calves are taken from their mothers and sold generally in October. When the calves are sold they weigh approximately 400 lbs. each.

Central Market---If the calves are shipped to a central market from Montana, St. Paul may be considered as a typical destination of the shipment.

The calves are trucked to a railroad point about 15 miles from the ranch. They are weighed (400 pounds each) and loaded on the stock cars and shipped to St. Paul. En route there are two feed and rest stops, where the calves are fed 150 pounds of hay per car at each stop, and water is available. These stops are for approximately 8 hours each in order that the animals may eat, lie down, and rest. When the stock arrive in St. Paul they are weighed again. If a ten percent shrink is assumed, the weight upon arrival is 360 pounds per animal.

If there are 100 calves sold at a weight of 360 pounds each the producer would have a gross return of \$7,200.00 for the calves when a price of \$20.00 per hundred weight is assumed.

Auction Market---The calves may be sold through a local auction mar-

ket which is located at the railroad shipping point. The stock are trucked into the market and sold through the auction ring very soon after arrival. They are sold on the basis of a 5% shrink on an actual 380 lb. weight each. ^{1/} The returns are \$7220.00 for 100, 380 pound calves, at an assumed price of \$19.00 per hundredweight.

Direct to purchaser---by this is meant a sale direct to the packer or feeder at the local shipping point through bargaining between the producer and purchaser. The buyer offers to pay \$18.80 per hundredweight and asks for a 4% pencil shrink. Again the producer receives \$7,220.00 gross returns for the calves.

To the producer it may at first appear that all three sales alternatives will yield approximately the same return for the calves he sells. In order that any major net differences can be determined it is necessary to include the costs of marketing the animals in each sale channel. To do this thoroughly, a set of alternative budgets may be set up previous to the sale in order that definite knowledge is gained with respect to the problem at hand.

Within the budget the production and sales operation are found to be approximately the same up to the railroad shipping point. Also, the gross income is found to be approximately the same in each case.

The difference lies in the expenses incurred in selling the stock through the different channels and in price differences. The differences

^{1/} Shrinkage rate is determined from material in Table V on calves shipped by truck a distance comparable to the 15 miles.

in costs of marketing may be sufficiently great that one method can be determined as preferable over the others.

Upon completion of the alternative budgets the expenses of selling the stock, through the central and auction markets, are found to exceed the costs entailed by selling direct to the purchaser. The costs entailed by selling through the central market are also above those incurred in the local auction market. As has been stated, the costs for all methods are equal up to the shipping point, but beyond that stage the calves sold through the auction require the following additional expenditures above those required when a direct sale is made. These are: 1/

Insurance, Yardage and Commission - - - \$309.00

Total \$309.00

The central market sale required the following expenditures over and above those made through the local auction: 2/

Veterinary inspection \$15.00 (state laws)

Feed and handling en route \$80.00 (approximately)

Transportation \$384.00

Total \$679.00

By a comparison of these total cost figures, it is seen that the auction costs exceed direct sale costs by \$309.00 and also that the central market costs exceed the auction costs by \$479.00. The central market costs are \$769.00 more than the direct sale costs.

1/ The source of these figures is data obtained in the livestock marketing study Project WM4 in current study -- See Table XIII and XIV, appendix.

2/ Ibid.

costs are \$788.00 greater than the direct sale costs.

The spread or margin allowed for shrinkage between local sales (auction and direct) and central market is \$1.00 (\$20.00 minus \$19.00) per hundredweight. The margin that should have been allowed for costs other than shrinkage to obtain equal net returns, between sales direct to purchaser and local auction market is \$.81 per hundredweight. The margin that should have been allowed between the auction market and the central market for costs other than shrinkage is \$1.26 per hundredweight based on loading weight. The margin to allow between direct sale to purchaser and central market for costs other than shrinkage is \$2.07 per hundredweight based on the loading weight of the calves. With these margins the price offers should have been, \$20.00 per hundredweight at the central market, \$18.74 per hundredweight at the auction market, \$17.93 per hundredweight on the direct sale to purchaser.

These are all purely theoretical cases, and figures, and it should be realized that a different pattern of prices and costs may be obtained under various conditions. It should also be realized that all buyers bid a price according to those prices available elsewhere. A method of determining the price differences through a budget analysis may be helpful in showing spreads among prices.

To analyze the sales procedures and obtain the price margins; costs, sales weights, and shrink conditions must be ascertained. The same animals (calves) observed in the previous section may be used for the analysis. The 100 head of calves would reach the central market with a 10 percent shrink and the sales weight would be 36,000 pounds. The costs for the

calves shipped to St. Paul include:

Veterinary inspection	\$15.00 (state laws)
Feed and handling en route.	80.00
Transportation.	384.00
Insurance, Yardage & Commission	309.00
Total cost if sold on arrival	788.00
Extra feed and water per day after arrival . .	61.00
Total costs if sold one day after arrival. . .	849.00
Total costs if sold four days after arrival. .	1032.00

If the animals are sold on arrival at a theoretical price of \$20.00 per hundred, the gross return will be \$7,200.00, and the net return will be \$6,412.00. If the calves are sold one day after arrival the shrink may be decreased from 10% to 6%, and the sales weight will be 37,600 pounds. The cost for the additional day is equal to \$61.00 and to net the same amount as was received on arrival the sales price would have to be \$19.30 per hundred. The calves will probably gain back most of their weight lost, in four days in the yards. ^{1/} If they are fed over that period, the sales weight will be about 39,200 pounds, (regain of 8%). The total cost will be \$1,032.00 so in order to net a similar \$6,412.00, the sale price could drop to \$19.00 per hundred.

If the calves are not shipped to a central market, but are sold at the local auction, there are a few possibilities to follow. The sale may be made on the day of arrival, or any number of days after arrival. If

^{1/} See Table V of this study.

three possible sale days are examined in this case, the following sold on arrival, one day after arrival, or four days after arrival may be representative:

The costs to the seller when he sells his stock through the auction may be listed as follows:

Insurance, yardage, feed, and commission ---	\$294.00
Feed and handling per day after arrival ---	61.00
Total cost if sold on day of arrival ---	309.00
Total cost if sold one day after arrival ---	370.00
Total cost if sold four days after arrival -	553.00

If the seller is to net the same amount obtainable at the central market using the \$20.00 per hundred price as a base, the price paid on the day of arrival at the auction must be \$17.69 per hundred if a shrink of 5% is assumed.

This price is required when a shrink of 5% is assumed as occurring prior to sale in the afternoon. The total sales weight would then be 38,000 pounds. When the calves are sold one day after arrival they may have regained some of the weight lost the day before and present a total sales weight of 38,800 pounds with 3% shrink in effect. To cover costs and receive a net return on the sale of \$6,412.00 the price must be \$17.48 per hundred. The calves may make a gain back to their original weight, if fed in the auction yards for four days after arrival. This would give a total sales weight of 40,000 pounds. The price now must be \$17.41 per hundred to net the producer \$6,412.00 on the sale.

The last major sales channel to be discussed is, direct to purchaser.

This method would entail no extra costs. The purchaser may demand a certain shrinkage but will usually bid according to the shrinkage asked. If the purchaser offers to take the animals with no shrink, the price must be \$16.03 per hundred in order to net the \$6,412.00 obtainable elsewhere.

If the buyer wants to purchase the animals on a pencil shrink (say 3 percent), then the total sales weight would be 38,800 pounds, and the price would be \$16.53 per hundred to obtain a net \$6,412.00.

When an overnight (say 4 percent) shrink is asked, then the price will be \$16.70 per hundred to net \$6,412.00 on 38,400 pounds.

In summarizing the prices that must be received at all sales outlets observed, to obtain a net return on the sale of \$6,412.00, Table XV may be observed.

Of course, allowances are sometimes made for risk and uncertainty when sales are made and this would be another possible factor to consider. Nevertheless, it seems that a producer should certainly stand on his own judgment and on budgetary calculations in order that he will know which sales method would be the most profitable under various conditions.

Table XV. Prices Required from Different Sales Channels, to Net Equal Returns.

Price* per Hundred	Sales Channel	Time of Sale	Condition of Sale
\$ 20.00	Central Market	On arrival	10% shrink
19.30	Central Market	One day after arrival	6% shrink
19.00	Central Market	Four days after arrival	2% shrink
17.70	Auction Market	On arrival	5% shrink
17.50	Auction Market	One day after arrival	3% shrink
17.40	Auction Market	Four days after arrival	No shrink
16.70	Direct to Buyer		Overnight shrink(4%)
16.55	Direct to Buyer		Pencil shrink (3%)
16.05	Direct to Buyer		No shrink

Source: Hypothetical Data Presented Earlier in this Paper.

*Figures are rounded to the nearest .05.

PART IV

Summary and Conclusions

A. Summary of Investigation.

Livestock marketing is important to both producers and meat consumers. Approximately one-third of the farmers income is derived from livestock and about one-fourth of the consumers food expenditures go for meat. 1/

The livestock industry constitutes approximately one-half of the farm cash receipts in Montana. 2/

Within the marketing industry there is a large marketing cost due to location of producers in the west, and the major part of the consumers residing east of the Mississippi river. One of the major items, which constitute marketing costs, is animal shrinkage. Information on shrinkage is also very inadequate, consequently an investigation into this problem seems rather justifiable.

An economic investigation into cattle shrinkage is necessarily limited by time and finances available. Consequently much of the material used in this dissertation was obtained from the Montana Branch Experiment Stations at Havre and Miles city, with some supplementary material taken from records of shipments made by Montana ranchers and dealers.

Most of the material used was primary data, since very little secondary information was available. Literature on the subject of hog shrinkage

1/ United States Department of Agriculture, Bureau of Agricultural Economics, Agricultural Statistics, 1952.

2/ United States Department of Agriculture, Bureau of Agricultural Economics, Farm Production, Disposition and Income, Washington, D.C., April 1953.

is available to a greater extent than on cattle shrinkage. Data on cattle shrinkage is either not current or is inadequate for analyzing the entire problem of cattle shrinkage in Montana.

The empirical data were analyzed to determine the extent of shrinkage in the different classes, age, and sex groups of cattle in the state. Calves, dry cows, feeder steers, feeder heifers, slaughter steers, and slaughter heifers were observed according to the gross shrinkage or shrinkage in transit and net shrinkage or shrink after refill at sales yard. A considerable difference was observed between gross shrink and net shrink, depending upon the number of hours allowed for a refill after shipment. Variation within all groups was noticeable, depending upon the different conditions surrounding the handling and shipping of the animals.

Numerous factors were defined as being possible influences on the shrinkage of cattle, but only four of the more important factors were used in a statistical analysis of shrinkage. The four factors, which were assumed to be the most important with respect to shrinkage, were, loading weight of the animal (X_2), number of hours spent on rail en route to market (X_3), the number of hours at feed and rest stops (X_4), and the number of hours allowed for a refill after shipment was complete (X_5). When set up in a correlation analysis these factors gave the estimating equation:

$$X_1 = .6483 + .77545X_2 - .4377X_3 - .02041X_4 - .26131X_5$$

This equation shows a positive relationship between pounds of shrink (X_1), and loading weight, and a negative relationship between pounds of shrink and hours en route, hours at feed and rest stops, and hours allowed for a refill. These relationships seem logical with the exception of the

negative correlation between pounds of shrink and hours en route. A positive relationship is more feasible and is illustrated by the regression equation $Y = 6.34 + .026X$ on feeder steers on page 39 of this study.

The corrected correlation coefficient was $\bar{R} \ 1.2345 = .54$ and the coefficient of determination was $\bar{R}^2 \ 1.2345 = .29$ when calculated in the multiple correlation analysis. This leaves 71 percent of the variation in shrinkage unexplained. This would seem to point up the large number of factors which might be responsible for variations in shrinkage.

To analyze the empirical evidence by the use of economic tools several economic models and assumptions were set up in Part III. The assumptions that it is desirable to maximize social welfare, that an individual beef producer faces a perfectly elastic demand curve, that the "Theory of the Firm" is in effect, and that an optimum position for a firm would take place where marginal cost equals marginal revenue, are all made. These assumptions are made in reference to the specific problem of cattle shrinkage.

B. Extent to Which Hypotheses Were Substantiated.

An excessive shrinkage of cattle in transit is indicated by evidence which shows that shrinkage can be reduced at a cost below the added revenue obtained through the reduction, under current price conditions. As long as this reduction is economical, then the current shrinkage may be indicated as being excessive. The equality of marginal cost and marginal revenue indicates the point of optimum conditions at which excessive shrink is eliminated.

A loss to society through tissue shrinkage is probably due to the lack of knowledge and improper management of individual firms (producers or dealers) concerned with the livestock industry. If a firm is unable to reach the optimum equilibrium then his income will not be maximized and society as a whole will absorb a loss.

The large number of factors responsible for shrinkage can be illustrated by the use of a correlation analysis. Although the factors believed to influence shrinkage the most were used in this study, only 29 percent of the variation in shrink is explained by four relatively important variables. The four variables used included: weight of the animal, hours on rail en route to market, number of hours at feed and rest stops, and the number of hours between arrival and sale. The factors left 71 percent of the variation in shrinkage to be explained by other factors, obviously, numerous other factors have not been considered.

A reduction in shrinkage is possible through the control of factors that affect shrinkage. Although many factors are responsible for the variation in shrinkage, a greater control of each factor would make it possible to place more beef on the market through a shrinkage reduction.

Reduction in shrink would be economical under certain price relationships. If the price of beef is proportionately greater than the price of factors used to control shrinkage, the control would be economical. Whenever the cost of reduction exceeds the returns obtained through the reduction, the reduction would not be economical.

By reviewing the hypotheses, with respect to the material used to test them, it can be seen that all of the hypotheses projected earlier

in this study have been substantiated by the investigation.

C. Recommendations Based on the Findings of this Study.

Since shrinkage can be reduced economically under the prevailing conditions, it is advisable for an effort to be made by producers and dealers to decrease the amount of shrinkage that occurs.

The first thing that is necessary in obtaining a reduction in shrinkage is the determination of the extent of shrinkage. To do this it is necessary to obtain an accurate record of the original weight. Many ranchers feel that scales, installed on the ranch, will pay for themselves many times over during their lifetime, by giving the producer a definite selling basis and accurate weight for shrinkage calculations. In view of this fact, ranchers and producers could be advised to install scales at their ranch headquarters.

Another recommendation to those concerned with livestock marketing, is careful control of all factors listed in this study which may influence shrinkage. This control may be incurred at a small expense in many cases, and in some cases at no expense. Even if an expense is undergone, it is still economical to reduce shrinkage as long as the price relationships mentioned previously are favorable. The best advice that can be given is for the people handling livestock to be very careful with the stock while they are in the marketing process. Many dollars are lost through carelessness and inefficiency of livestock handlers. At times this loss is incurred unknowingly, but in any case more care could be taken to prevent shrinkage. The proverbial saying that "An ounce of prevention is worth

a pound of cure", is certainly applicable to the shrinkage problem. Consequently, it is recommended that all possible aspects of the sales problem be carefully analyzed. A complete analysis of the problem, and alternative solutions to the problem, can be made by the use of the budget method. A little time and effort spent in this manner could mean an increase in net returns to the person or persons concerned.

D. Suggestions for Further Research

Throughout the course of this investigation it has been evident that the data used were not entirely adequate to answer all of the problems with respect to cattle shrinkage. In view of this fact, a suggestion for further research would be in the form of a partially controlled study. This study could be carried out similar to other controlled studies in the physical sciences. The main object of the study would be to obtain complete data on all factors surrounding cattle shipments. Factors that could be partially controlled include: finished weights, hours en route to market, hours at feed and rest stops, hours in yards previous to sale, feed and water throughout the shipment, and handling of the animals. Factors that could not be controlled include: temperature or climate, and progeny or family line of the animal. Nevertheless, all conditions could be observed and recorded. After complete data were obtained on an adequate number of shipments, a very detailed and rigorous empirical analysis would be accomplished. This analysis should avoid one of the big weaknesses incurred in this present study. This weakness is the assumption of linear relationships between shrinkage and other factors. There may be linearity

in some cases, but in others a curvilinear analysis would be best to define the true relationships that exist. Curvilinear analysis has not been carried out in the current study due to inadequacy of the data used. The analysis of detailed accurate empirical data should include the use of economic tools in both a practical and theoretical setting.

A P P E N D I X

Appendix A
Questionnaire

WESTERN REGIONAL LIVESTOCK COST OF MARKETING STUDY - WM 4

MONTANA STATE COLLEGE, AGRICULTURAL EXPERIMENT STATION

Name of shipper _____ Address _____

Number, Class, Breed and Kind of Cattle:

Number in shipment	{	Calves _____	Wet Cows _____	Indicate kind by check	{	Slaughter _____
		Heifers _____	Dry Cows _____			Feeder _____
		Steers _____	Other _____			Stocker _____

Indicate breed with check	{	Hereford _____	Crossbred _____
		Shorthorn _____	Angus _____
		Dairy _____	

Handling and Feeding Prior to Initial Weighing:

A. Feed used prior to weighing (check appropriate line and column)

Kind of Feed	12 hours prior	12 to 48 hours	2 to 7 days	More than 7 days prior
Dry range				
Green pasture				
Pasture and grain				
Dry lot feed				
Off feed and water				
Other				

- B. 1. If calf shipment - were calves cut from mothers and weighed immediately? yes _____ no _____
2. How long prior to shipment were they off mothers? _____ days.

C. Movement to scales and/or loading point

2. Miles by truck _____, cost \$ _____ Total hours off feed before weighing _____.
- Miles by truck _____, cost \$ _____ Total hours off water before weighing _____.

Initial Weighing:

- A. Place weighed _____, date and hour weighed _____, date last scale inspection _____.
- B. Hours elapsed between weighing and loading . . . _____ gross weight at shipping point _____.

Movement of Livestock from Initial Weighing Point to Destination:

- A. Method of transportation: rail____, truck____, cost per cwt. \$____
or total \$_____.
- B. Destination____, miles____
hours in transit_____.
- C. If livestock were fed and watered in transit, give the following data
when available:

Place	Hours rest and feed	Cost of feed & handling	Off car weight	On car weight

Handling at Destination:

- A. Date and hour unloaded____, off car weight____, to whom
consigned_____.
- B. Date and hour of sale____, sale weight____, sale
price \$_____.
- C. Were livestock fed and watered at market? yes____, no____.

Expenses Paid at Market for this Shipment:

Yardage \$____, commission \$____, feed \$____, insurance \$____
other_____ Total_____.

Explain any Unusual Weather, Feed, Water or Handling Conditions that could
Affect Shrinkage of Shipment: (If additional space is needed please use
back of schedule.)

- A. At ranch_____
- B. At shipping point, if not at ranch_____
- C. In transit_____
- D. At market_____
- E. Other comments_____

If Livestock Were Sold on Contract Prior to Delivery, List Contract Terms:

- A. Percentage shrink _____, hours off feed and water _____ miles
driven _____.
- B. Contract price \$ _____, down payment \$ _____, date of contract
_____.

Grade and Yield of Slaughter Livestock:

- | | |
|---------------------------|-------------------------|
| A. Estimated live grade | B. Actual carcass grade |
| 1. No. choice _____ | 1. No. choice _____ |
| 2. No. good _____ | 2. No. good _____ |
| 3. No. medium _____ | 3. No. utility _____ |
| 4. No. _____ | 4. No. _____ |
| C. Estimated yield _____% | D. Actual yield _____% |

Appendix B
Supplementary Tables

Table XIII Sales costs for selling calves through various auctions in Montana, 1953

Location	Commission & other yard costs*	Cost of feed for one extra day
Bozeman	\$2.90	\$.80
Billings	\$2.54	\$.51
Butte	\$2.85	\$.70
Missoula	\$2.10	\$.45
Havre	\$3.50#	No Data
Lewistown	\$3.38	\$.65
Great Falls	\$2.90	\$.65
Glendive	\$3.10	\$.75
Glasgow	\$3.80#	\$.50
Sidney	\$3.80#	\$.50
Averages	\$3.09	\$.61

*Includes commission, yardage, insurance, and feed during sale day.

#Includes commission, yardage, insurance, feed one day before and also sale day.

Table XIV Cost of freight on feeder stock shipped from various points in Montana to St. Paul, Minnesota, 1953

Origin	Destination	Effective freight/cwt.
Missoula	St. Paul	\$1.13
Billings	St. Paul	\$.90
Havre	St. Paul	\$.90
Butte	St. Paul	\$1.08
Miles City	St. Paul	\$.77
Average freight from Montana to St. Paul. --		\$.96/cwt.

BIBLIOGRAPHY

- Abbenhaus, Gerald R., and Penny, Roland C., Shrink Characteristics of Fat Cattle Transported by Truck, Chicago Union Stock Yard and Transit Company, Chicago, Illinois, 1951.
- Dowell, A. A. and Bjorka, K., Livestock Marketing, McGraw-Hill Book Company Inc., London and New York, 1941.
- Due, John F., Intermediate Economic Analysis, (Chicago, Illinois, Richard D. Irwin, 1951).
- Heady, Earl O., "Economic Models in Farm Production Economics Research," Journal of Farm Economics, XXX (May, 1948).
- Jacobsen, N.A., and Willson, E.A., Marketing Costs of Feeder Calves Montana to Ohio, Montana Experiment Station, July, 1949, Unpublished data.
- Miscellaneous data from Montana Branch Experiment Station, Havre, Montana, 1946-1952.
- Miscellaneous data obtained from auction markets in Montana, see Appendix Table XIII.
- National Resources Board, Report of the Land Planning Committee, Washington, D.C., December, 1934, Part II.
- Nervick, Ottar, Marketing South Dakota Feeder Cattle, Bulletin 409, Agricultural Experiment Station, Brookings, South Dakota, 1951.
- Quenemoen, M.E., Economic Aspects of Water Spreader Developments on Southeastern Montana Ranches, (Montana Experiment Station, December, 1952).
- Reder, Melvin Warren, Studies in the Theory of Welfare Economics, Columbia University Press, New York, 1951.
- Snapp, Roscoe R., Beef Cattle, Their Feeding and Management in the Corn Belt States, John Wiley and Sons, Inc., New York, 1950.
- Stevens, Ira M., et al, Marketing Western Feeder Cattle, Wyoming Agricultural Experiment Station, Bulletin No. 317, Laramie, Wyoming, June 1952.
- United States Department of Agriculture, Bureau of Agricultural Economics, Agricultural Statistics, 1952

United States Department of Agriculture, Bureau of Agricultural Economics,
Crop Reporting Board, Livestock and Poultry on Farms and Ranches,
January 1, 1953.

United States Department of Agriculture, Bureau of Agricultural Economics,
Farm Production, Disposition and Income, Washington D. C., April,
1953.

United States Department of Agriculture, Bureau of Agricultural Economics,
The Livestock and Meat Situation, January, 1950.

Ward, W. F. and Downing, James E., United States Department of Agriculture,
Bureau of Animal Industry, The Shrinkage in Weight of Beef Cattle
in Transit, (December, 1913).

Wilcox, R. H., R. D. Jennings, G. W. Collier, W. H. Black and E. W. McComas,
Costs and Methods of Fattening Beef Cattle in the Corn Belt,
1919-1923, U.S.D.A. Technical Bulletin 23, December, 1927.

Wright, J. Stewart, Montana Sheep and Cattle Shrinkage in Transit, Montana
Experiment Station, May, 1942.



N378 P975e Cop.2 Purnell, G.R. Economic analysis of cattle shrinkage	
NAME AND ADDRESS	
APR 9 '57	INTERLIBRARY LOAN Univ. of Arizona Lib.
MAR 16 '59	Dale Hurdle
JUN 28 '61	Mark Clark
	R JUL 10 '61
	R JUL 20 '61
	R
SE 19 '61	

N378
P975e
Cop.2

108571