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The Implications for Cattle Producers of Seasonal Price Fluctuations

by

R. O'CONNOR

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The Implications for Cattle Producers of Seasonal Price Fluctuations

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November 1968. R. O'CONNOR.

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The Implications for Cattle Producers of Seasonal Price Fluctuations

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SUMMARY

For many years Irish farmers have benefited to a considerable extent from the guaranteed prices for fat cattle in Britain but despite this link with British payments, prices of all classes of cattle in Ireland are very variable. There is variation by year, by season, by age and by sex.

Annual price variations

Farmers who buy and sell cattle are perhaps as well off when prices are low as when they are high. In times of high prices the farmer gains more from the weight put on during the feeding period than in times of low prices but as against this the value of his investment increases considerably and so the percentage return on capital may be less than it was when prices were lower.

The people who generally do best in times of high prices are the breeders who sell calves. Calf prices practically always increase when prices of finished cattle go up and *vice versa*. The coefficient of correlation between actual store cattle and calf prices and between percentage changes in these prices for the years 1951 to 1967 are ·83 and ·72 respectively. These coefficients are highly significant.

Seasonal price changes

In Ireland seasonal price changes are very marked. Prices are at their highest in Spring or early Summer each year and at their lowest in Autumn. For the 12 years 1956 to 1967 the average decline in prices between April and November was 30s. per cwt. The seasonal pattern was very constant over the years in question despite fairly wide swings in the price levels between different years.

The published prices show that bullock prices in any month are higher than those for heifers of comparable weights. Up to the middle of 1965 prices per cwt. for light cattle were higher than those for heavier animals. Around this time however, a change in the price pattern took place. Prices of light and heavy cattle came closer together and gradually the previous trend was reversed so that in recent years heavier cattle are fetching the highest per cwt. prices.

Summer grazing

Summer grazing is the cheapest form of production but because of the drop in prices between Spring and Autumn the returns per animal tend to be low. Many farmers are prepared to accept such low returns because of the convenience and low labour requirements of the system.

For cattle gaining 3½ cwt. the average gross output per animal from summer grazing for the years 1963 to 1967 was only about £12 and if variable costs estimated at £3 per animal are deducted the gross margin was only about £9 per animal. Hence the summer grazier needs a very large acreage of land if he is to make a reasonable family income from this enterprise.

Most profitable selling date for summer-fed cattle

There is usually little to be gained by keeping saleable cattle on pasture beyond the end of July if these cattle are not to be over-wintered. It is usually more profitable to cut the late growth for silage rather than feed it to such cattle in late Summer or early Autumn.

Stocking rates for summer-fed cattle

Consideration of stocking rates over the whole of the grazing season is not very realistic since there is little to be gained in most years from keeping cattle (which must be sold before winter) on grazing from July onwards. Stocking rates for such cattle should therefore be considered for the early part of the season only.

At prices ruling in 1963 which was a fairly typical year the farmer who could get a gain of 2 cwt. per acre from one animal from April to the end of June would probably need to obtain over 2·6 cwts per acre from two cattle carried on the same land area, before the keeping of the extra animal would be justified.

Winter feeding

The feeding of cattle in Winter requires much higher capital expenditure than does summer grazing but because of the large price rise between Autumn and Spring, profits from the system usually justify the extra expenses, if the farmer can make good silage at a reasonable cost. The farmer who cannot make good silage on the other hand should be wary about erecting expensive buildings for the winter feeding of cattle.

If the price rise over the Winter is expected to be very high (i.e. more than a quarter of the selling price) the farmer who has limited feed should spread it over as many cattle as possible by feeding the animals at maintenance rates. If on the other hand the seasonal price rise is expected to be less than a quarter of the selling price, the farmer should normally feed for weight gains. In only one of the years since 1950 was the price rise more than a quarter of the selling price, hence it can be taken that as a general rule feeding for weight gain over the winter is more profitable than feeding for maintenance.

November to June feeding

This system usually gives lower outputs per acre than November to April feeding but output figures tend to be misleading in this context. If all the grass which grows on a farm is saved for winter feeding, costs are much higher than if some of it is grazed by animals. In the former case more animals are required for the shorter feeding period and hence there are greater marketing expenses and other costs. More housing space is also required which again adds to expenses and of course there is the additional cost of ensiling all the grass rather than feeding some of it as grazing.

Whether or not a farmer should incur these costs depends mainly on his expectations regarding weight gains over the winter compared with these over the grazing period, and on the magnitude of the expected price decline between April and June. Because of the number of variables which must be considered, it is difficult to make any simple, general statement on this question. However from the analysis undertaken the following appears to be justified.

When the weight gain per animal over the grazing period is 1·6 cwt. or more, very high price declines between April and June would have to occur before a grazing programme would be unjustified. This is especially true where the quality of the silage is poor and cattle make low gains over the Winter. On the other hand if the gain over the grazing period is low (say less than 1·5 cwt.) the position is different. In this case unless wintering costs are very high and winter price rises very low a small price decline from April to June makes spring grazing of well wintered cattle uneconomic relative to sale in April. For the farmer who is a poor silage maker and who obtains low gains over the Winter, June selling is likely to be the most economical system in all cases.

Feeding grain along with hay or silage

The decision to feed grain during Winter in addition to roughage (hay or silage) depends on many factors, the principal ones being the quality of the roughage, the expected selling price of beef and the cost of the different feeds. If the roughage is of poor quality it may be essential to supplement it with some grain otherwise the cattle may become emaciated or even die. If the roughage is of reasonably good quality the decision to feed grain depends on the beef/grain and the beef/silage price ratios (i.e. price of beef per cwt. divided respectively by price of grain per cwt., and by the cost of silage per cwt.).

When the beef/grain price ratio is no more than 5·0/1 it seldom pays to feed grain along with reasonably good silage. Thus if barley costs 30s. per cwt. and cattle are expected to sell for less than 150s. per cwt. grain feeding is seldom a profitable undertaking unless the cost of silage is very high. On the other hand when the beef/grain price ratio is 5·5/1 or greater it usually pays to feed some grain at all normal silage costs.

The analysis shows that at present prices for cattle and barley, heavy grain feeding of small cattle is justified unless the cost of making silage is very low. The extra margins however from grain feeding over those from full feeding on good silage are however not very great and farmers would lose little by feeding less grain than recommended by the analysis. On the other hand since grain is likely to improve the degree of finish of the cattle, the feeding of barley along with silage may give higher margins than those shown by the analysis.

THE IMPLICATIONS FOR CATTLE PRODUCERS OF SEASONAL PRICE FLUCTUATIONS

Cattle are produced in Ireland to supply both the home and export markets. By far the most important export market is the U.K. where Irish cattle are required as stores and as fats to supplement other supplies. For many years, Irish farmers have benefited to a considerable extent from the guaranteed prices of fat cattle in Britain. Irish cattle are not directly eligible for the British fatstock prices* but if they spend a short period on British farms they become eligible. Hence, large numbers of Irish stores are sold evey year to British farmers for further feeding. While the supply of cattle is relatively stable depending mainly on the size of the cow herd, the number of stores required in Britain varies from year to year depending on such factors as home supplies, weather, fodder supplies etc. Therefore, despite the link with British payments, prices for store cattle in Ireland and for that matter prices of all cattle, are very variable. There is variation by year, by season, by age and by sex.

*As a result of the 1966 Free Trade Agreement between the United Kingdom and the Irish Republic, certain subsidies are now paid on Irish dead meat exported to the U.K.

Annual price fluctuations

Some idea of the annual variation in cattle prices is obtained from an examination of the prices of fat cattle at Dublin Market for some years which are given in Table 1 and Figure 1. Store prices show a somewhat similar variation. (See Table 2 and Figure 2).

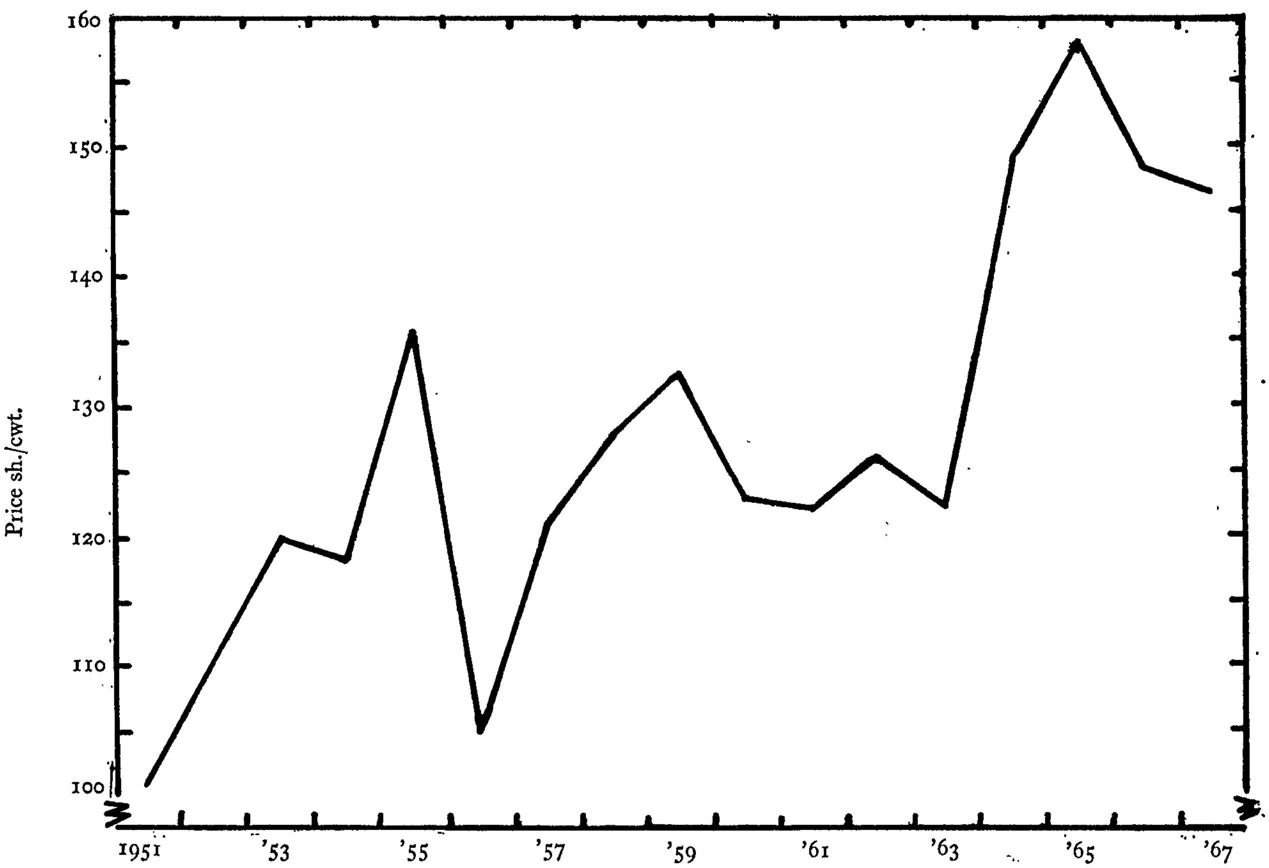
TABLE 1: AVERAGE ANNUAL PRICES PER CWT.† OF FAT CATTLE AT DUBLIN MARKET, 1951–1967

Year	Price	Year	Price	Year	Price	Year	Price
	s. d.		s. d.		s. d.		s. d.
1951	101 3	1955	135 9	1959	132 6	1963	122 3
1952	110 9	1956	105 0	1960	122 9	1964	148 9
1953	120 0	1957	121 3	1961	122 0	1965	158 0
1954	118 6	1958	127 9	1962	126 0	1966	148 3
						1967	146 6

Source: March issues of *Irish Trade Journal and Statistical Bulletin* 1952–1963 and *Irish Statistical Bulletin,* 1964 to 1968.

†All weights given in this paper are liveweights.

FIGURE 1: AVERAGE ANNUAL PRICE PER CWT. OF FAT CATTLE AT DUBLIN MARKET, 1951–1967



As can be seen from Table 1 fat cattle prices in Dublin rose by 34s. 6d. per cwt. from 101s. 3d. in 1951 to 135s. 9d. in 1955. They declined by 30s. 9d. per cwt. between 1955 and 1956 and rose again by 27s. 6d. between 1956 and 1959. Between 1959 and 1961 they dropped by 10s. 6d. per cwt. They rose slightly in 1962, dropped again by a small amount in 1963, rose substantially from 122s. 3d. in 1963 to 158s. 0d. in 1965, declined to 148s. 3d. in 1966 and to 146s. 6d. in 1967. These changes are shown diagrammatically in Figure 1.

In order to assess properly the effect of such large annual price changes on farmers' profits, we must be clear as to what is meant by profits from cattle raising. Normally we consider that the gross profit (or gross output) is the difference between sale and purchase values. Many cattle farmers however would not agree with this definition. They would consider that their gross profit is the amount left over when the land is restocked, the assumption being that a constant number of animals is kept on the land at all times. Under such conditions this is a valid method of arriving at what we might call the farmer's cash output. The amount of money left when he has replaced his stock is the actual amount available to pay his farm and household bills and provide for saving.

In assessing gross profits in this way, no account is taken of the farmer's capital position. The change in the value of stocks between the beginning and end of the period under review is ignored. The value of stocks cannot of course be ignored if the system of farming is not stable from year to year or if the net worth of the farmer has to be considered. If, on the other hand, a stable system of cattle farming is carried on over the years, the change in the value of stocks is of no more than academic interest and is often referred to as a paper profit or loss.

We must not assume from all this that ordinary accounting procedures (which record the stock and cash situation) are misleading or wrong. These procedures are designed to cover all kinds of situations. They show both the cash and the stock position in any period and the farm manager can select the result which best suits his situation. In cases where the system of farming is unchanged from year to year and where the number of animals carried each year is similar, the cash output is the relevant figure. In cases where the system of farming varies from year to year, where different types and numbers of stock are carried in different years or where stock are not replaced for some time after sales, the change in the value of stocks must be taken into account.

TABLE 2: RELATIONSHIP BETWEEN PRICE PER HEAD AT FAIRS OF STORE CATTLE 2–3 YEARS OLD AND CALVES UNDER 1 MONTH OF AGE, 1951–1967

Year	Prices of;		Prices as % of Previous Year	
	Store Cattle	Calves	Store Cattle	Calves
	£	£		
1951 ..	36·05	5·15		
1952 ..	40·30	5·70	111·8	110·7
1953 ..	45·85	8·90	113·8	156·1
1954 ..	45·70	8·05	99·7	90·4
1955 ..	50·15	9·40	109·7	116·8
1956 ..	41·45	8·80	82·7	93·6
1957 ..	48·25	10·30	116·4	117·0
1958 ..	53·95	16·45	111·8	159·7
1959 ..	53·00	16·60	98·2	100·9
1960 ..	48·35	10·10	91·2	60·8
1961 ..	50·55	10·25	104·6	101·5
1962 ..	53·15	11·65	105·1	113·7
1963 ..	52·15	11·90	98·1	102·1
1964 ..	58·65	14·55	112·5	122·3
1965 ..	60·45	18·15	103·1	124·7
1966 ..	53·85	12·05	89·1	66·4
1967 ..	55·20	8·85	102·5	73·4

Source of prices: March issues of *Irish Statistical Bulletin*, formerly *Irish Trade Journal and Statistical Bulletin*, C.S.O., Dublin.

The above discussion would seem to indicate that farmers who buy and sell cattle and who carry the same amount of stock at all times are just as well off when prices are low as when they are high. There is a certain amount of truth in this statement but it is not entirely correct. If no account is taken of stocks the difference between the selling value and the replacement value is the gross profit. If the selling value is high, the replacement value is also high so that at such times the farmer is not as well off in terms of cash as many people are inclined to think. On the other hand, if the selling value is low the replacement value is correspondingly low and the farmer is not as badly off as might be thought. The difference between selling and replacement value will *not* be the same in both cases however, because the farmer gains more from the weight put on during the feeding period in times of high than of low prices. An important point in this connection is that in times of high cattle prices the value of a farmer's investment increases substantially and the percentage return on capital in terms of cash output may be less than it was when prices were lower.

A further point is that the people who usually do best in times of high cattle prices are the breeders who sell calves. High prices for finished cattle create a demand for store cattle and this in turn creates a demand for calves, so that calf prices generally (though not always) increase when prices of older cattle go up. They also usually decline when prices of older cattle go down (see Table 2 and Figure 2). Hence breeders who sell calves suffer most in times of depressed prices. The coefficients of correlation between actual store cattle and calf prices and between year to year percentage changes in these prices for the years 1951 to 1967 are ·83 and ·72 respectively. These coefficients are highly significant. The breeders of course have their own problems in times of high cattle prices. The demand for heifers for both slaughter and breeding increases substantially in these years and heifers to replace the older breeding cows become exceedingly expensive.

Seasonal price fluctuations

In addition to the annual price changes, there is also a seasonal price movement between Spring and

FIGURE 2: AVERAGE ANNUAL PRICE PER HEAD AT FAIRS OF STORE CATTLE 2–3 YEAR OLD AND CALVES UNDER 1 MONTH OLD, 1951–1967

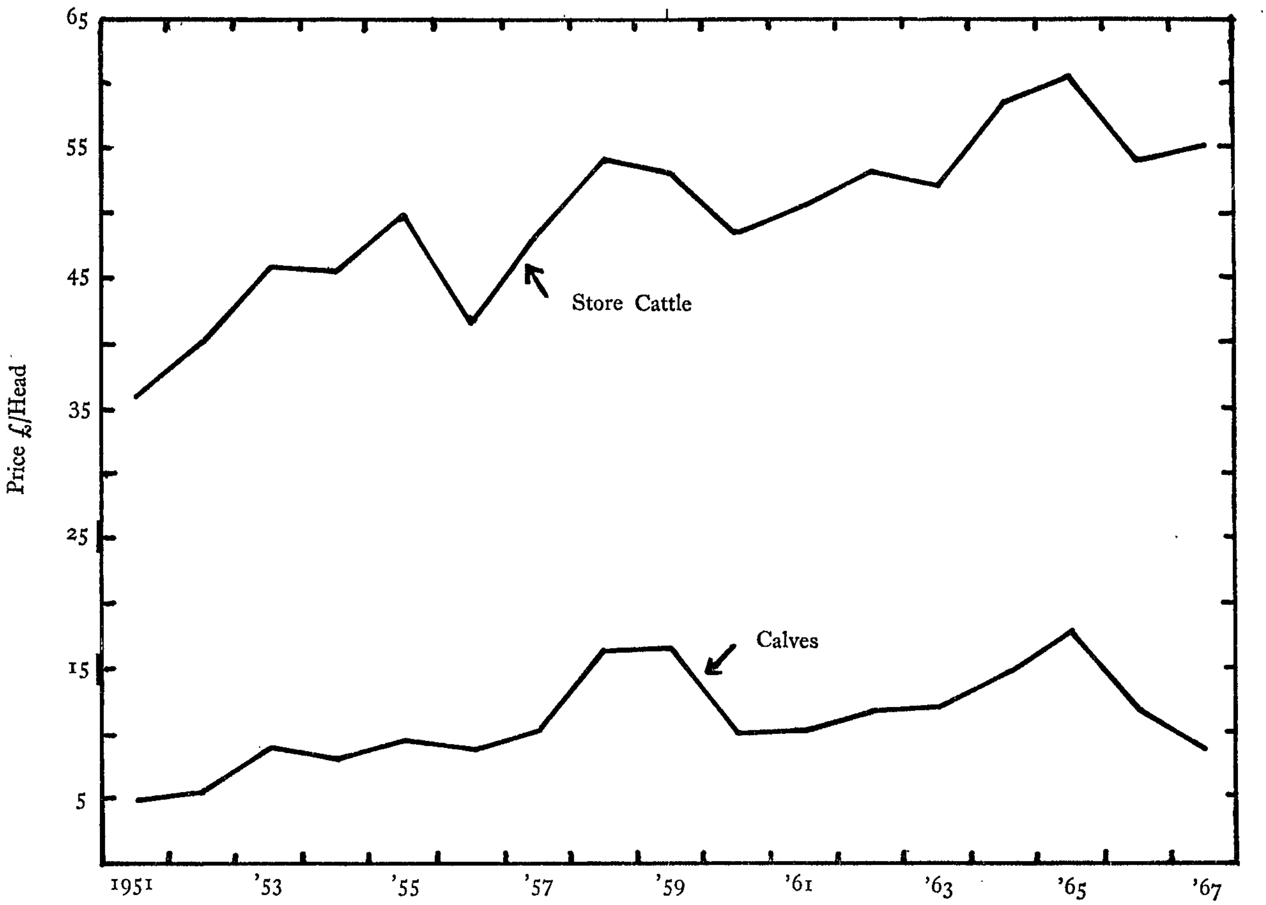
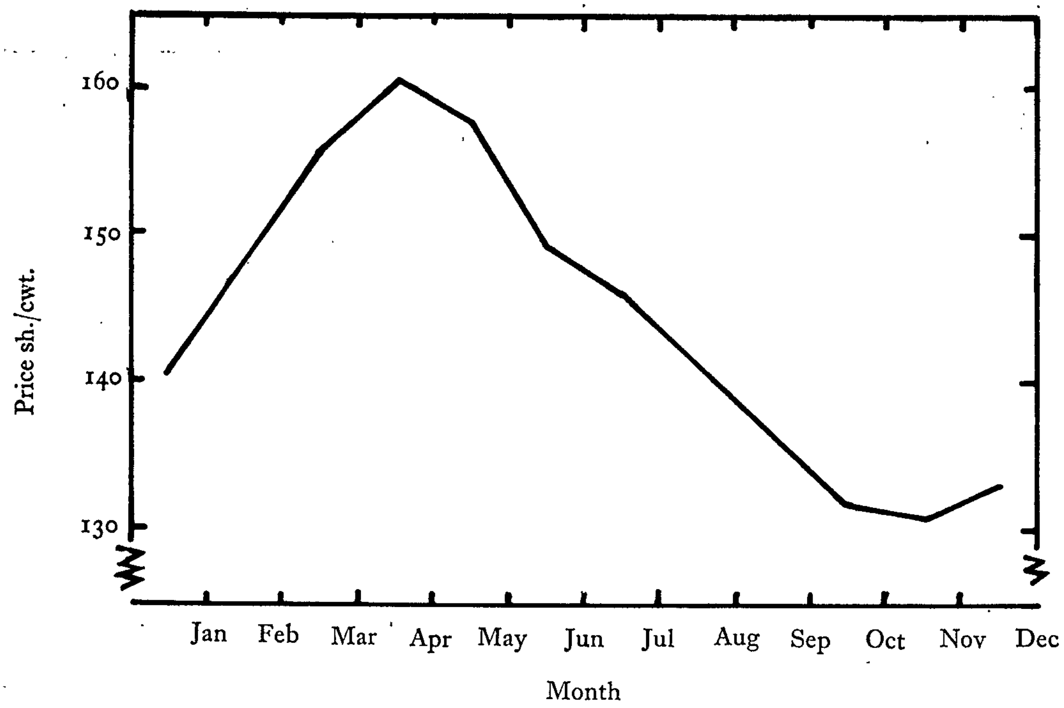


TABLE 3: MONTHLY PRICES PER CWT. OF STORE BULLOCKS AT DUBLIN AUCTIONS 1956–1967

Year	Jan.		Feb.		March		April		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.	
	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.
1956 ..	121	6	119	3	119	9	125	0	118	3	112	0	111	9	104	3	97	0	100	0	96	9	97	3
1957 ..	114	6	127	3	141	3	150	9	139	3	131	3	135	3	138	6	132	9	127	6	128	0	129	6
1958 ..	135	9	139	3	146	0	151	3	158	3	151	9	151	3	145	0	143	0	131	6	132	3	129	0
1959 ..	141	3	154	0	162	3	168	0	158	0	151	3	143	6	135	6	128	3	129	6	127	9	131	9
1960 ..	142	6	146	9	147	3	156	9	152	3	140	0	137	3	134	9	129	0	123	6	120	3	121	6
1961 ..	131	9	140	9	152	3	153	0	142	6	134	6	134	6	132	6	134	3	131	3	131	9	136	9
1962 ..	153	3	156	6	156	9	158	3	163	0	152	9	147	9	143	9	140	0	133	3	130	3	129	9
1963 ..	135	9	140	0	146	6	151	0	156	0	149	6	148	6	142	6	134	6	129	6	126	0	127	9
1964 ..	143	0	156	6	165	6	172	3	176	0	169	6	165	3	159	3	151	9	148	3	151	0	155	3
1965 ..	170	6	178	0	183	9	187	9	180	0	174	3	170	6	164	0	154	0	146	6	144	6	147	6
1966 ..	154	9	160	6	174	3	179	3	180	3	171	9	162	3	147	0	139	9	132	3	128	3	131	0
1967 ..	143	6	154	0	170	0	173	6	165	3	153	9	146	0	148	6	149	9	147	6	153	3	161	0
Average	140	6	147	9	155	6	160	6	157	6	149	3	146	0	141	3	136	3	131	9	130	9	133	0

Source : Irish Trade Journal and Statistical Bulletin and *Irish Statistical Bulletin.*

FIGURE 3: AVERAGE MONTHLY STORE BULLOCK PRICES AT DUBLIN AUCTIONS, 1956–1967



Autumn. In Ireland, prices of fat and store cattle are on average about 30s. per cwt. lower in Autumn than in Spring though this seasonality is often masked to some extent by the year to year fluctuations. Average monthly prices of store bullocks at Dublin auctions for the years 1956 to 1967 are shown in Table 3 and Figure 3 to illustrate the seasonality of cattle prices. Fat cattle prices show a similar seasonal pattern.

As can be seen from Table 3 and Figure 3 prices are at their highest in Spring or early Summer each year and at their lowest in Autumn. Taking the average of the 12 years 1956–1967 the highest monthly price was 160s. 6d. in April and the lowest 130s. 9d. in November (see Figure 3). This seasonal pattern of prices was very constant over the years in question despite fairly wide swings in the price levels between the different years. Thus in 1956 when cattle prices were very low, the price in April at 125s. was 28s. 3d. per cwt. higher than in November. In 1964 when prices were much higher, the difference in price between April and November was 21s. 3d. The largest seasonal difference of 51s. 0d. per cwt. occurred in 1966 and the lowest of 19s. 0d. in 1958.

The prices in Table 3 are unsuitable for assessing accurately the effect of buying and selling at different seasons of the year because they are not classified by weight of animal. Those in Appendix A which became available for the first time in 1963 are more suitable for this purpose. The figures in this Appendix relate to monthly cattle prices for animals of different weights at livestock marts throughout the country in the years 1963 to 1967 and show that bullock prices in any month are higher than those for heifers of comparable weights. (See Figure 4). This price difference which is somewhat higher for light than for heavy cattle has tended to decline slightly in recent years. The average difference for 7–8 cwt. cattle was about 12s. per cwt. in 1963 compared with about 8s. per cwt. in 1967.

Many reasons are put forward as to why heifers fetch lower prices than bullocks but most of them tend to derive from the fact that beef heifers may prove in-calf and upset feeder's expectations. If an Irish store heifer proves to be in-calf on a British farm she becomes ineligible for the fatstock deficiency payment and will generally be less profitable than an animal qualifying for this payment. As a proportion of Irish store heifers always prove in-calf in Britain, prices are downgraded to allow for this risk.

Another reason put forward for low heifer prices is that for a given degree of finish, heifers have a higher proportion of fat to lean (particularly kidney fat) than bullocks and so give a lower proportion of high priced cuts than the latter. The capacity for growth is considered to be a factor in this question also. Heifers have a lower growth potential than bullocks and on this account are downgraded in price on store markets. It is also claimed that because of their heat periods, heifers are troublesome to herd, but it is doubtful if this is a very important cause of low prices.

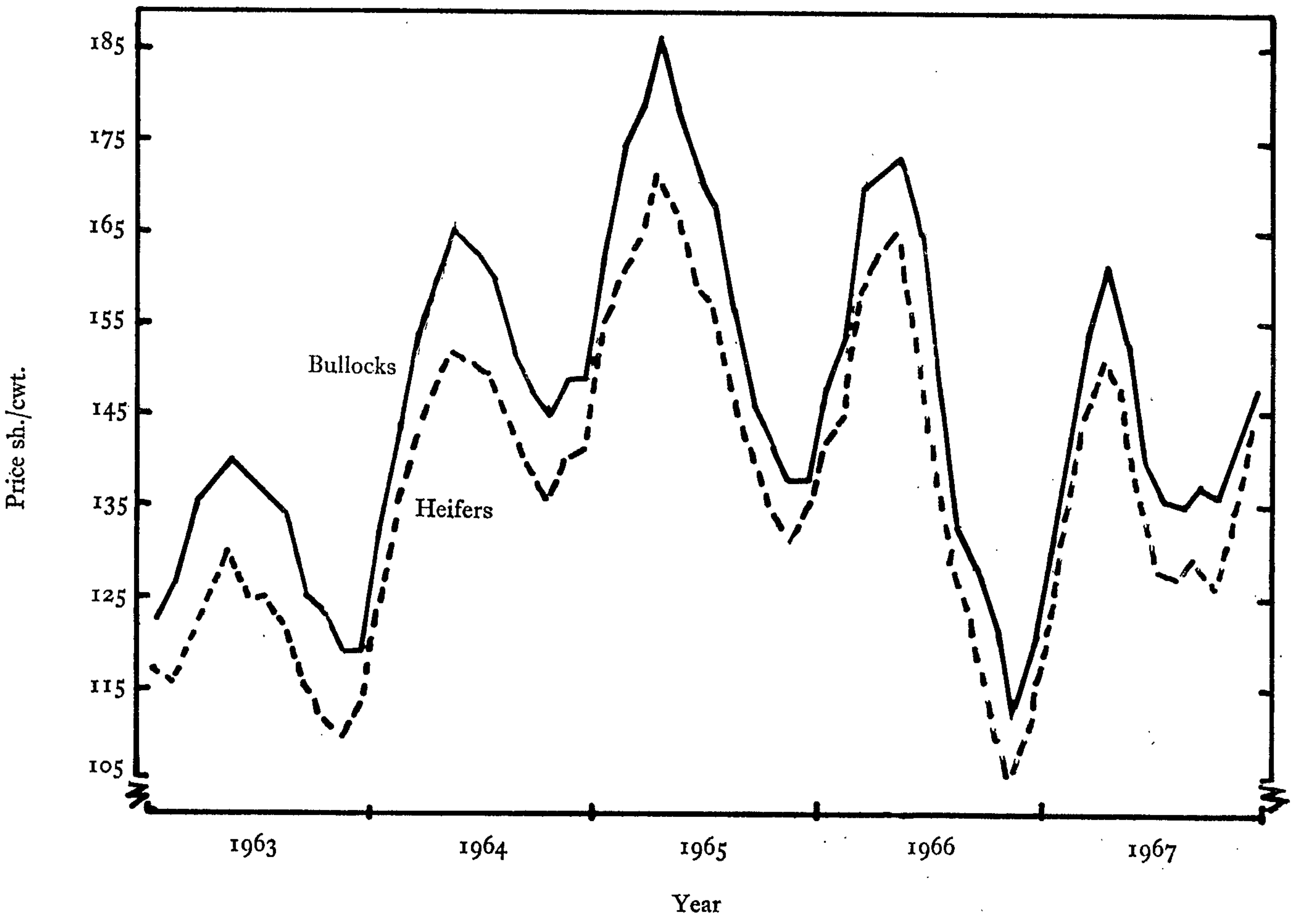
It can be seen from Appendix A also and more clearly from Figure 5 that up to the middle of 1965, prices per cwt. for light cattle were higher than those for heavier animals. Around this time however a change in the price pattern took place. Prices of heavy and light cattle came closer together and gradually the previous trend was reversed so that in recent years heavier cattle are fetching the highest per cwt. prices. This changed price pattern seems to be related to the introduction of a subsidy for carcase beef in February 1965 which has been continued in subsequent years following the 1966 Anglo-Irish Free Trade Agreement. Prior to 1965 Irish store cattle were eligible for British subsidies after spending a short time on British farms and so these animals fetched higher per cwt. prices than the heavier fat cattle for which there was no similar subsidy. The present subsidy on carcase beef however more than offsets the traditional store/fat price difference.

Profits from cattle farming are affected very much by seasonal price changes. Summer grazing is the cheapest form of production but because of the drop in prices between Spring and Autumn, the output per animal tends to be low. However, many farmers are prepared to accept such low outputs because of the convenience and low labour and building requirements of this system.

The feeding of cattle in Winter requires much higher capital expenditure than does summer grazing since it usually involves the provision of housing and of conserved winter feed. These latter are expensive items and a substantial price rise between Autumn and Spring is necessary in order to justify the system.

There are of course various modifications of these two extreme systems, some of which are discussed below. In this discussion it is assumed that farmers receive the average prices for stock shown in Appendix A. It should be kept in mind of course that

FIGURE 4: AVERAGE PRICE PER CWT. OF BULLOCKS AND HEIFERS OF 7½ CWT. AT LIVESTOCK MARTS FOR YEARS 1963–1967



there is a wide variation in prices within any weight range and that good quality animals will fetch higher than average prices and poor quality ones lower prices.

Buying in Spring and selling in Autumn

To determine the effect of buying in Spring and selling in Autumn we take the case of a 6½ cwt. bullock purchased in April, kept on fairly good pasture over the Summer and sold in November of the same year weighing 10 cwt. The gross output from such a beast at the prices ruling in livestock marts for the years 1963 to 1967 are shown in Table 4.

TABLE 4: GROSS OUTPUTS IN DIFFERENT YEARS FROM SUMMER GRAZING

Year	Purchase Price	Sale Price	Gross Output
	£ per animal		
1963 ..	45·9	56·3	10·4
1964 ..	52·2	70·5	18·3
1965 ..	61·8	68·0	6·2
1966 ..	55·2	59·5	4·3
1967 ..	50·9	72·7	21·8
Average	53·2	65·4	12·2

As can be seen the gross output from this system varied from about £22 per beast in 1967 which was an exceptionally good year for this kind of enterprise* to about £4 per head in 1966 which was an exceptionally bad year.

The average for the five years was about £12 per animal and when variable costs such as fertiliser, veterinary, marketing, transport and other variable expenses, all estimated at £3 per animal, are deducted the gross margin† per animal is only about £9. This is a rather low return for such a large weight gain. It normally takes an acre of pasture to carry one such animal over the summer, hence both the return per animal and per acre from summer grazing is normally very low. Accordingly the summer grazier needs a very large acreage of land in order to make a reasonable family income from this enterprise alone.

The rather low returns from buying cattle in Spring and selling them in Autumn are due to the fact that there is a heavy loss on the weight purchased. In the years in question the average price for a 6½ cwt. bullock would be about 165s. per cwt. and the same weight would be sold in October or November at an average of about 131s. per cwt. The direct loss on the weight purchased in those years would therefore be about £11 10s. This loss has to be counterbalanced by the weight gain valued at the low autumn price. It is obvious therefore that very high summer weight gains must be obtained in order to make any reasonable profit. When allowances are made for rates, annuities and marketing costs (fertiliser being omitted) a weight gain of almost 2 cwt. per animal, over the grazing period is normally required in order to break even.

In view of the low returns from summer grazing it seems curious that farmers rent pasture for this purpose. There are many reasons for this. Grazing is very often rented to supplement a farmer's own land, the cattle on the rented land not always being purchased in Spring or sold in Autumn; they may be carried on the farmer's own land during either the preceding or subsequent Winter. Many people renting land are part-time cattle dealers who buy and sell when prices are favourable and who use the land for holding purposes. Also in times of good cattle prices, farmers become optimistic about the future and hope to increase their incomes substantially by the renting of land for grazing purposes.

Most profitable selling date

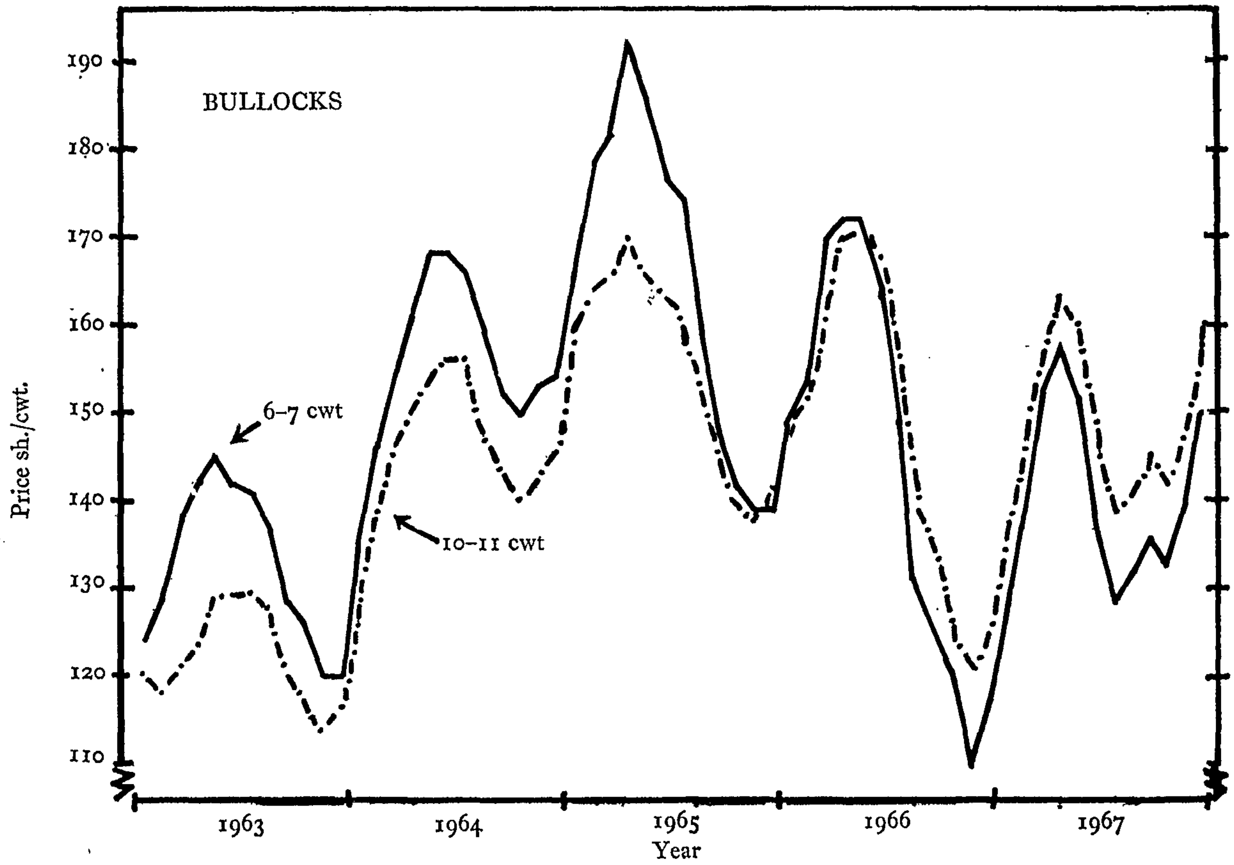
In the above discussion it was generally assumed that cattle were purchased in April and sold in November. Many graziers however buy and sell at dates other than these. In particular they sell their cattle at various times from June onwards depending on prices and on the rate of growth of the pasture. The performance of cattle on grass tends to decline from the middle of June onwards; prices generally fall during this period also. Hence farmers tend to sell off some or all of their cattle during the Summer before prices decline too much. The economics of selling in different months will of course vary with the season and with prices ruling in any year. In years when growth is good during Summer and Autumn, or when the price decline is less than normal it may be more profitable to sell late than early, unless the late growth is needed for silage making. In some years it may be profitable to sell in Summer or early Autumn even though the late growth is not utilised.

When the weight gain is about 3½ cwt. per animal over the period April to October the seasonal distribution of gain in Ireland is on average probably similar to that shown in Table 5. This table shows that July was the most profitable selling month in 1963. Cattle kept after this date would lose money despite the weight gains during the remainder of the season. For all practical purposes July was also the most profitable selling month in 1964. Cattle kept until the end of October

*The high prices ruling for cattle in November 1967 were no doubt due to some extent at any rate to the outbreak of foot and mouth disease in Britain in that year.

†Gross margin is defined as sale price less purchase price less variable costs (i.e. gross output less variable costs).

FIGURE 5: GRAPHS SHOWING AVERAGE PRICES PER CWT. OF BULLOCKS AND HEIFERS IN CERTAIN WEIGHT CLASSES AT LIVESTOCK MARTS FOR YEARS 1963–1967.



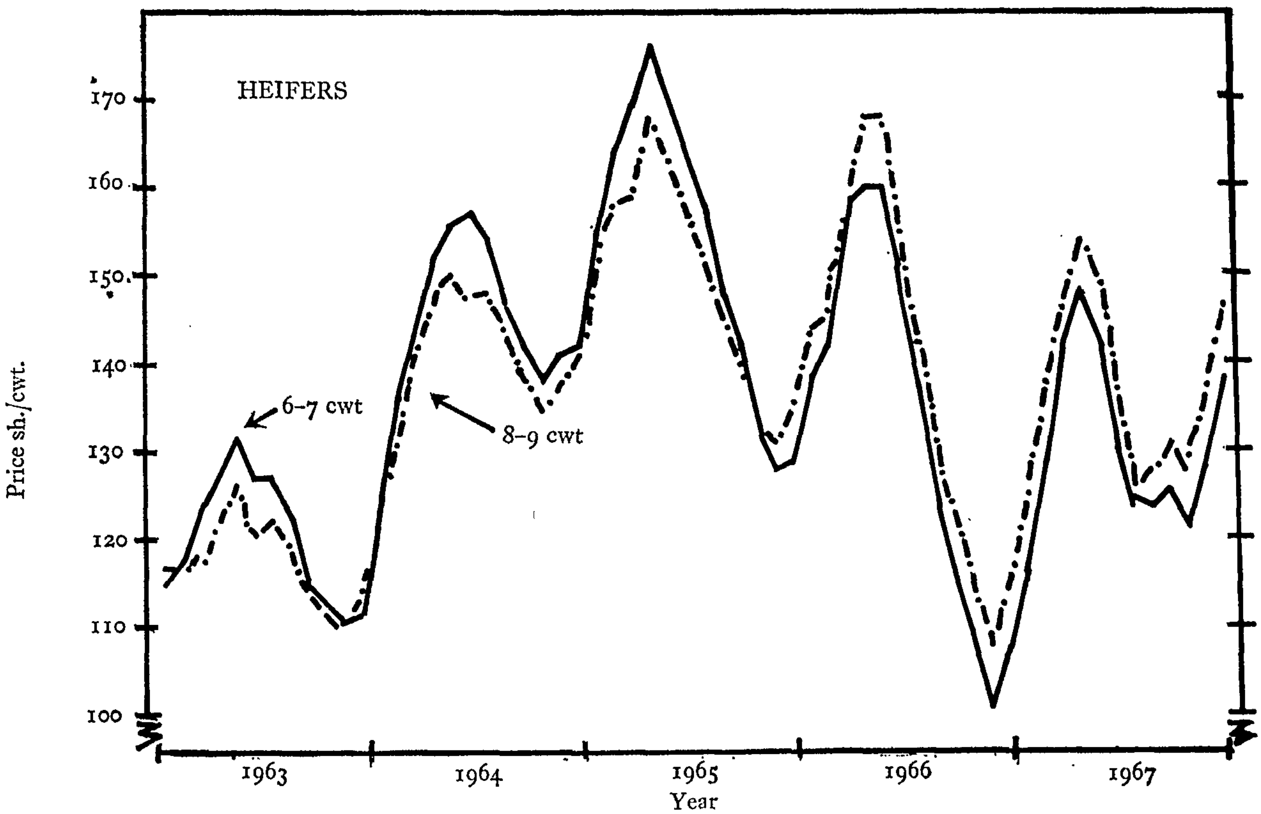


TABLE 5: MONTHLY WEIGHT GAINS AND VALUES FOR CATTLE MAKING 3½ CWT. GAIN OVER GRAZING SEASONS 1963–1967

	Weight gain lb./day *	Total Weight cwt.	1963		1964		1965		1966		1967	
			Price £/cwt.	Value £	Price £/cwt.	Value £	Price £/cwt.	Value £	Price £/cwt.	Value £	Price £/cwt.	Value £
1 April ..	—	6·50	7·00	45·5	8·15	53·0	9·41	61·2	8·50	55·3	7·73	50·2
30 April ..	2·02	7·04	6·96	49·0	8·10	57·0	9·10	64·1	8·61	60·6	7·79	54·8
31 May ..	3·11	7·90	6·83	54·0	8·04	63·5	8·52	67·3	8·39	66·3	7·40	58·5
30 June ..	2·46	8·56	6·78	58·0	7·93	67·9	8·30	71·0	7·90	67·6	7·02	60·1
31 July ..	1·95	9·10	6·67	60·7	7·68	69·9	8·01	72·9	7·20	65·5	6·95	63·2
31 Aug. ..	1·44	9·50	6·33	60·1	7·32	69·5	7·61	72·3	6·78	64·4	7·12	67·6
30 Sept. ..	1·23	9·83	6·07	59·7	7·08	69·6	7·16	70·4	6·44	63·3	7·15	70·3
31 Oct. ..	0·61	10·00	5·81	58·1	7·02	70·2	6·81	68·1	6·11	61·1	7·21	72·1

* Based on estimated gains of "tester" animals for four years 1961 to 1964 on leys in Moorepark, Fermoy—See Browne, D. "Nitrogen use on grassland—effect of applied nitrogen on animal production from a ley", *Irish Journal of Agricultural Research*, Vol. 5, No. 1. (April 1966).

in that year increased only marginally above the July values. July was again the most profitable selling month in 1965, June in 1966 and October in 1967.

Examination of prices in other years confirms the view that in most years at the weight gains assumed in Table 5 July is the most profitable selling month for summer cattle feeders. The late growth may be either conserved for silage or left for winter forage. From a technical point of view it is, of course, far less wasteful to conserve grass for silage than leave it for winter grazing. But despite the wastage, winter grazing may often be more profitable than autumn utilisation by cattle which are sold in October and November.

The above statements regarding selling dates do of course depend on the seasonal distribution of weight gains selected. Distributions from other experiments when budgeted out, have however not changed the general conclusions in any way and indeed have confirmed the view that in most years early selling is the most profitable course. Indeed because of the very high price drop exceptionally large weight gains have to be obtained in the autumn months before it normally pays to feed cattle for sale towards the end of the growing season.

Economics of stocking rates for summer graziers

Over the whole grazing season heavily stocked pastures usually give higher weight gains per acre but lower gains per animal than less heavily stocked areas.[1] Consideration of stocking rates over the whole grazing season is however not very realistic since as was shown in the previous section there is little to be gained in most years from keeping cattle on grazing from July onwards if these cattle are not to be overwintered. Stocking rates for such cattle should therefore be considered for the early part of the season only. It can be taken that in later months they are of no more than academic interest.

Conway[2] has shown that for the first few months of grazing in the year, there is practically no difference in animal performance between certain levels of stocking, and states that in trials at Grange they have found that with two cattle to the acre until early July the weight gain per animal was the same as that from cattle stocked at one animal per acre. Under these conditions of course no subtle economic problem appears to be involved. The land which heretofore carried one animal per acre can now give the same gain per animal if the cattle are confined to half the grazing area leaving the remainder free for further cattle, for hay or silage or for renting out.

Economic problems arise under conditions where the weight gain per animal declines and the weight gain per acre rises as more animals are carried on a given area. Because of the price decline over the grazing season there is a loss on every cwt. purchased which must be counterbalanced by the weight gain, and the problem is to determine the stocking rate at which this balancing takes place on different classes of land for varying numbers of cattle. On very fertile land such as that in Grange the comparison might be between animals stocked at rates of 2, 2½, or even 3 per acre whereas on less fertile land the comparison would be between animals stocked at much lower rates.

The economics of stocking rates can be explained by reference to an example in which we assume that a 6½ cwt. bullock purchased in April is carried on 1 acre of land until the end of June making a weight gain of 2 cwts. At 1963 prices the gross

[1] Conway, A. "Effect of grazing management on beef production," *Irish Journal of Agricultural Research,* Vol. 2, No. 2, October 1963.

[2] Conway, A. "Grazing management in relation to beef production," *Irish Grassland and Animal Production Assoc. Journal,* 1968, pp. 9–10.

output from such an animal would be about £11. It can be determined from formula (1) below that for a similar output per acre in the same year from two animals, the weight gain would need to be about 1·13 cwt. per animal or 2·26 cwt. per acre and when account is taken of the extra costs for two cattle the weight gain would need to be about 2·6 cwt. per acre in order to break even.

If we assume that cattle having the same initial weight in April decline in price by the same amount over the grazing period regardless of their weight gains, the stocking rates that break even with one animal per acre can be calculated from the formula given below. The assumption of a constant price decline for differently stocked cattle is not entirely realistic and (at present price trends) will bias the results in favour of heavier stocking rates. In practice however this bias should be small since average prices (such as those given in Appendix A) covering fairly wide weight ranges have to be taken in doing the analysis. It should be mentioned in this connection however that the more prices move in favour of heavier cattle the less the argument in favour of heavier stocking rates if the latter system means the production of lighter cattle.

The break-even stocking rate formula (under the assumption of an equal selling price per cwt. for all cattle) which has been derived as shown in Appendix B can be written as follows:

(1) $x_n = \frac{1}{n}\left[\frac{(W_1 a + c)(n-1)}{P_2} + x_1\right]$ or as

(2) $n x_n = \frac{(W_1 a + c)(n-1)}{P_2} + x_1$

Where:

x_1 = the weight gain per animal at a stocking rate of one animal per acre (cwt.)

x_n = the weight gain per animal at a stocking rate of n animals per acre (cwt.)

n = the number of animals per acre

W_1 = the initial weight per animal (cwt.)

P_2* = the selling price (£ per cwt.)

a* = the decline in price per cwt. between purchase and sale taken as a positive number (£), and

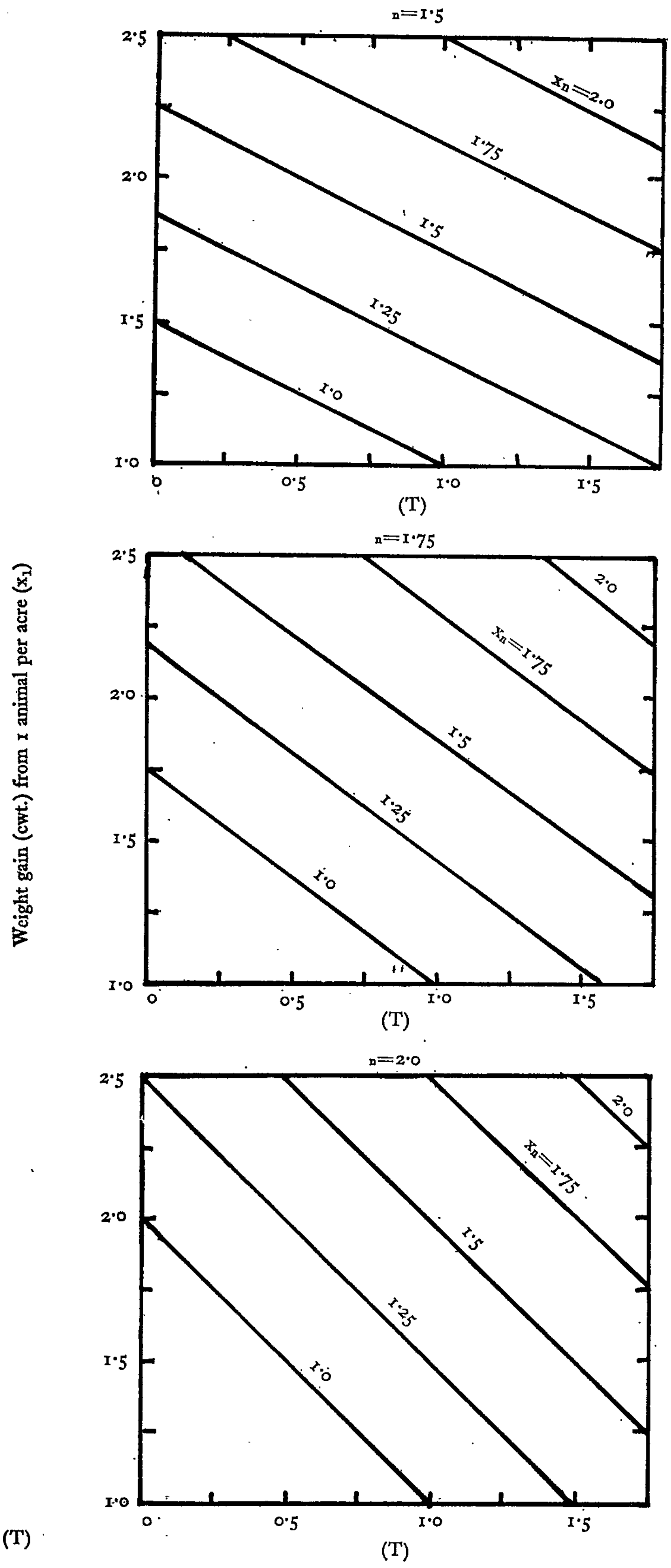
c = variable costs per animal other than fertilisers (£).

*It should be stated that when using this formula the values of "P_2" and "a" will be unknown and the user will have to make the best estimate he can of what their values will be.

TABLE 6: WEIGHT GAINS PER ANIMAL UNDER DIFFERENT STOCKING RATES TO BREAK EVEN WITH 1 ANIMAL PER ACRE

Difference between buying and selling price [£ per cwt. (a)]	Weight gain from 1 animal per acre (X_1)								
	1·5			2·0			2·5		
	Number of animals per acre (n)								
	1·5	1·75	2·0	1·5	1·75	2·0	1·5	1·75	2·0
	Weight gain per animal to break even with 1 animal per acre (x_n)								
	(Initial weight 6½ cwt.; selling price £7 per cwt.)								
0·25	1·17	1·08	1·01	1·51	1·37	1·26	1·84	1·65	1·51
0·50	1·25	1·18	1·13	1·58	1·46	1·38	1·91	1·75	1·63
0·75	1·33	1·28	1·24	1·66	1·57	1·49	1·99	1·85	1·74
1·00	1·41	1·38	1·32	1·74	1·66	1·57	2·07	1·95	1·82
1·25	1·48	1·47	1·48	1·81	1·76	1·73	2·15	2·05	1·98
	(Initial weight 7½ cwt.; selling price £7 per cwt.)								
0·25	1·19	1·10	1·03	1·52	1·38	1·28	1·85	1·67	1·53
0·50	1·27	1·21	1·16	1·61	1·50	1·41	1·94	1·78	1·66
0·75	1·36	1·33	1·30	1·69	1·61	1·50	2·03	1·90	1·80
1·00	1·45	1·44	1·43	1·79	1·73	1·68	2·12	2·01	1·93
1·25	1·54	1·55	1·56	1·87	1·84	1·81	2·21	2·13	2·06
	(Initial weight 6½ cwt.; selling price £8 per cwt.)								
0·25	1·15	1·05	0·98	1·49	1·34	1·22	1·82	1·62	1·48
0·50	1·22	1·14	1·08	1·55	1·42	1·33	1·89	1·71	1·58
0·75	1·29	1·22	1·18	1·62	1·51	1·43	1·95	1·79	1·68
1·00	1·35	1·31	1·28	1·69	1·60	1·53	2·02	1·89	1·78
1·25	1·42	1·40	1·39	1·75	1·69	1·64	2·09	1·97	1·89
	(Initial weight 7½ cwt.; selling price £8 per cwt.)								
0·25	1·16	1·06	0·99	1·49	1·35	1·24	1·83	1·63	1·49
0·50	1·24	1·17	1·11	1·57	1·45	1·36	1·91	1·74	1·61
0·75	1·32	1·26	1·23	1·65	1·55	1·48	1·99	1·83	1·73
1.00	1·39	1·37	1·35	1·73	1·65	1·60	2·06	1·94	1·85
1·25	1·47	1·47	1·46	1·81	1·75	1·71	2·14	2·04	1·96

FIGURE 6: WEIGHT GAINS PER ANIMAL (x_n) REQUIRED UNDER DIFFERENT STOCKING RATES IN ORDER TO BREAK EVEN WITH 1 ANIMAL PER ACRE



$\frac{W_1a+c}{P_2} = (T)$

The figures in Table 6 and in Figure 6 which have been prepared from the above formulae show the weight gains per animal under different stocking rates required to break even with one animal per acre for different purchase/sale price changes. In preparing Table 6 the animals are assumed to have initial weights of 6½ and 7½ cwt., the selling prices at end of June are £7 and £8 per cwt., and the variable costs other than fertilisers are taken to be £2 per animal. It is assumed also that cattle having the same initial weight in April decline in price by the same amount over the grazing period regardless of their weight gains.

Table 6 shows that for a constant gross margin per acre, heavy cattle must make greater weight gains over the grazing period than lighter cattle. This is only to be expected since for a given price decline, the loss on the weight purchased is greater when heavy rather than light cattle are acquired. Thus when animals stocked at the rate of one animal per acre make weight gains of 2 cwt. per acre over the grazing period and prices decline by £1 per cwt. from £7 to £6 the break-even gain per head for 6½ cwt. and 7½ cwt. animals stocked at the rate of two animals per acre are 1·57 and 1·68 cwt. respectively.

On the other hand for a constant gross margin per acre, cattle of similar initial weights must make somewhat greater weight gains when prices are low rather than when they are high. Thus when 6½ cwt. animals stocked at the rate of one animal per acre make weight gains of 2 cwt. over the grazing period and prices decline by £1 per cwt. from £8 to £7 the break-even gains for animals stocked at the rate of two animals per acre is 1·57 cwt. whereas for a similar price decline from £9 to £8 these animals must gain 1·53 cwt. in order to break even.

In using Figure 6 the value of the expression $\frac{W_1a+c}{P_2}$ must be calculated for each reading, but this should not prove an unduly onerous task. As an example of how the graph should be used we take the case of cattle having initial weights (W_1) of 6½ cwt. which if stocked at the rate of 1 animal per acre make a weight gain (x_1) of 2 cwt. If we assume that the selling price (P_2) is £7 per cwt., the decline in price (a) £0·5, and the variable costs (c) £2 per head, the value of $(W_1a+c)/P_2=0{\cdot}75$.

Now in order to determine for a stocking rate of 2 animals per acre the weight gain per animal required to break even with one animal we use the lower graph and read up from the 0·75 point on the horizontal axis and across from the 2·0 point on the vertical axis. These readings meet between the 1·25 and 1·5 lines and so we can say that the result is about 1·4 cwt. per animal or about 2·8 cwt. per acre. For a stocking rate of 1·75 animals we should use the centre graph and for a stocking rate of 1·5 animals the upper graph.

Buying in Autumn and selling in Spring

Many farmers exploit the seasonal price rise by buying in Autumn and selling in Spring. The profitability of this system depends ultimately on the price rise over the period and on the selling price of beef relative to that of feed. For given prices however the level of feeding must also be considered and in theory at any rate this level should depend on whether cattle or feed is the limiting factor in production.

If a farmer has a limited amount of feed and there is no limit on the number of cattle he can keep then he should aim to maximise profit per ton of feed. In these circumstances one would intuitively imagine that the farmer should not aim at high weight gains but should spread the limited feed over as many cattle as possible and rely on the seasonal per cwt. price rise for his profits. If on the other hand feeding space or capital for the purchase of cattle is limited and there is no limit on the amount of feed which can be produced or purchased, then it would seem that the aim should be to maximise profit per animal. In the latter circumstance it would appear that the farmer should adopt a higher level of feeding than in the former case.

Whether or not different feeding levels should be adopted in both these cases depends on cattle prices as well as on the limiting resource. If the price rise between Autumn and Spring is very high the farmer who has limited feed should spread it over as many cattle as possible. If on the other hand the seasonal price rise is average or lower than average the farmer should normally feed for weight gains. We explain below why this is so by reference to a practical example in which for simplicity cattle are assumed to be fed completely on silage.

Limiting Factor—Feed

Suppose a farmer has 48 tons of good silage which if fed at the rate of 56 lbs. per day is sufficient for the maintenance of a 6½ cwt. bullock, maintenance in this context being understood to cover all biological processes and allow for a slight weight gain due entirely to growth. It is also assumed that a further 25 lbs. of silage per day gives an additional 1 lb. gain per day. At the rate of 56 lbs. per day the animal consumes about 2⅝ tons of silage over the 4 month period November to March and gains ½ cwt. At this rate of feeding, 48 tons will carry 18 cattle for the period in question. If the animals are fed a further 25 lbs. of silage per day total daily consumption is 75 lbs., consumption over the whole period is 4 tons and weight gain is 1½ cwt. per animal. At this rate of feeding 48 tons of silage will carry 12 cattle for 4 months.

Let us assume that the initial price of the cattle is £6·5 per cwt. and that selling prices of all cattle (regardless of level of feeding) is the same.

The outputs from the two sets of cattle using four levels of price increases are given in Table 7 below. The price increases adopted are £1, £1·5, £2·0, £2·5 per cwt. The last level is rather unrealistic but has been used for illustrative purposes.

TABLE 7: GROSS OUTPUTS FROM 48 TONS OF SILAGE, ASSUMING DIFFERENT FEEDING RATES AND PRICES. (Initial weight of cattle 6½ cwt. Initial price £6·5 per cwt.)

	Group 1 (½ cwt. gain) 18 animals			
	Price Increase (per cwt.)			
	£1·0	£1·5	£2·0	£2·5
Initial value £	42·3	42·3	42·3	42·3
Final weight cwt.	7·0	7·0	7·0	7·0
Final price £	7·5	8·0	8·5	9·0
Final value £	52·5	56·0	59·5	63·0
Output per animal £	10·2	13·7	17·2	20·7
Output per 48 tons silage £	183·6	246·6	309·6	372·6
	Group 2 (1½ cwt. gain) 12 animals			
	Price Increase (per cwt.)			
	£1·0	£1·5	£2·0	£2·5
Initial value £	42·3	42·3	42·3	42·3
Final weight cwt.	8·0	8·0	8·0	8·0
Final price £	7·5	8·0	8·5	9·0
Final value £	60·0	64·0	68·0	72·0
Output per animal £	17·7	21·7	25·7	29·7
Output per 48 tons silage £	212·4	260·4	308·4	356·4

This table shows that when the price increase between Autumn and Spring is less than £2 per cwt. it is more profitable to feed the cattle well than to carry them on a maintenance ration. When the price increase is £1.5 per cwt. the gross output from 12 cattle fed almost to appetite on 48 tons of silage is about £260 whereas that from 18 cattle fed a maintenance ration is £247. When the price increase is £2 per cwt. the return from both sets of cattle is about the same but since fewer cattle are involved under the full feeding programme the latter system is preferable. When the price differential is £2·5 per cwt. the lighter rate of feeding gives a higher total output than the heavier feeding but again it is doubtful if this increase offsets the housing and other costs of the extra number of cattle involved.

The above results depend on the assumptions made regarding the quantities of silage required for maintenance and weight gain and also to some extent on the actual weights and prices of the animals. These points are apparent from the following "break-even" formula which shows the price and other conditions under which the same gross output is obtained from cattle fed for maintenance or for weight gain. The method of deriving this formula which assumes a linear relationship between feed intake and weight gain, is shown in Appendix B.

"Break-even" Formula

$$(3)\quad \frac{P_2-P_1}{P_2}=\frac{M/G-(W_2-W_1)}{W_1}$$

where P_1=Initial price (£ per cwt.)

P_2=Final price (£ per cwt.)

W_1=Initial weight (cwt.)

W_2=Final weight of animals fed at maintenance levels (cwt.)

M=Amount of feed required for maintenance (tons)

G=Amount of feed required per cwt. gain above maintenance (tons)

If (M/G) and (W_2-W_1) are constant this formula shows that for any given selling price (P_2) the output break-even price increase (P_2-P_1) is lower for heavy than for light cattle. Thus if W_1 is increased the expression on the right of the equality sign decreases. If at the same time the selling price (P_2) remains constant then if equality is to be maintained the price change (P_2-P_1) must decrease. Again if M/G and (W_2-W_1) are constant the formula shows that for an animal of a given initial weight (W_1) the output break-even price increase is higher at higher price levels. Thus if W_1 remains constant the whole expression on the right of the sign of equality remains constant also. If at the same time P_2 is increased (P_2-P_1) must also be increased if the equality of both sides of the expression is to be maintained. Accordingly the break-even price increase is not independent of the price level and because of this it may be more meaningful to write formula (3) as in (4) or (5) below:

$$(4)\quad \frac{P_1}{P_2}=\frac{(W_2-W_1)-M/G}{W_1}+1.$$

$$(5)\quad \frac{P_1}{P_2}=\frac{W_2}{W_1}-\frac{1}{W_1}\left(\frac{M}{G}\right)$$

where the initial/final price ratio is expressed as a function of the other factors.

The initial/final price ratios at which the same gross output is obtained from cattle fed for maintenance and for weight gain under different assumptions regarding the ratio of feed for maintenance to that for 1 cwt. gain are given in Table 8.

Different levels of M/G are postulated in this table because this ratio is likely to be higher for heavy than for light cattle.[3] Also in calculating the figures in Table 8 it is assumed that the weight gain for an animal fed at maintenance level over a period of four months is ½ cwt.

TABLE 8: OUTPUT BREAK-EVEN PRICE RATIOS FOR ANIMALS OF DIFFERENT INITIAL WEIGHTS
(Maintenance *v.* 1 cwt. gain above maintenance)

Maintenance/ gain, feed ratio (M/G)	Initial weight (W_1) cwt.				
	6·0	6·5	7·0	7·5	8·0
	Break-even price ratio P_1/P_2				
2·0	0·75	0·77	0·79	0·80	0·81
2·1	0·73	0·75	0·77	0·79	0·80
2·2	0·72	0·74	0·76	0·77	0·79
2·3	0·70	0·72	0·74	0·75	0·78

If we postulate that (M/G) is about 2·0 for animals of 6 to 7 cwt. and 2·2 for animals of 7 to 8 cwt. the figures in Table 8 show that for animals in these categories the initial price would need to be less than ¾ of the expected final price before the farmer should feed at maintenance levels. In the past four years the November/March or November/April price ratio for cattle in these categories has never been less than 75 per cent.* Hence it can be taken for the specified (M/G) values that with all except the very heaviest of cattle, feeding for weight gain over the winter is more profitable than feeding for maintenance. For very heavy cattle it may be more profitable to feed at lower rates but this is doubtful.

Of course, it takes very good silage to give the weight gains postulated above. If such silage is not available this gain cannot be obtained and all the farmer can do is feed the animals to appetite on what he has got. He may of course feed grain along with the silage but the economics of this feeding is a separate question.

It should be noted that in the above discussion the cost of feed did not enter into the equations. This is not to imply that feed costs are unimportant in such situations. These costs are of course very important but they must be taken into account at the time the silage is made and not at the time it is being fed.

The considerations to be taken into account at silage making are:

(1) The opportunity cost of making silage (i.e. the extra fertiliser for silage over that which would be used on pasture. The variable costs of cutting and ensiling the grass and the income sacrificed by not using the grass for grazing.) If a farmer has to reduce his stock of cows in order to produce silage for cattle feeding, then the opportunity cost may be quite high. This situation can occur on small dairy farms and in such cases winter feeding of cattle may not be a sound proposition. On large farms on the other hand where the alternative to silage may be autumn grazing the opportunity cost of silage may be little more than the variable cost of production.† Other considerations are:

(2) The variable costs other than feed, of wintering cattle (i.e. medicines, veterinary fees, transport and marketing, interest on capital, etc.);

(3) The expected purchase and sale price of cattle for wintering;

(4) The technical input–output coefficients (i.e. feed consumption for maintenance and per lb. gain above maintenance);

(5) The opportunity cost of investing capital in buildings and silos if such are not available and if the cattle cannot be outwintered.

If it is found from these considerations that wintering of cattle on silage is likely to be more profitable than summer grazing of cattle or of other stock, then silage should be made. Once made however the cost of production is irrelevant. From thence the only consideration is the most profitable method of utilisation. Though produced for cattle feeding it may in certain cases be more profitable to feed it to cows, calves or sheep but we ignore these considerations here.

In the case where feed is the limiting factor the level of feeding will be determined at feeding time depending mainly on the cattle prices ruling at that time and on the selling price expectations. This level may however be varied during the feeding period by purchase or sale of cattle if price expectations change.

Limiting Factor—Cattle

If cattle rather than feed is the limiting factor a somewhat similar type of formula can be developed to determine the most profitable feeding level. Strictly speaking in this situation the feeding of grain along with silage should be considered but we defer this consideration to a later section and discuss here the feeding of animals on silage alone. In this case the level of feeding must be determined at silage-making time so that the farmer knows the amount of silage he should make for the number of cattle he can keep. The feeding level will be determined by the same factors as in the other case

[3]Rations for Livestock P.51—Ministry of Agriculture Fisheries and Food. H.M.S.O. London 1960.

*The ratio was less than 75 per cent. in only one post-war year, i.e. 1956/57 when it was about 65 per cent.

†In practice opportunity costs are very difficult and sometimes impossible to estimate. In such cases the measurable costs are used instead and the returns from the enterprise (obtained using the latter costs) are compared with those from the competing enterprise, which is costed using its measurable costs.

except that now the farmer will be interested in maximising profit per animal rather than per ton of feed.

If we assume as in the previous case that for practical purposes the relationship between silage intake and weight gain is linear, then two feeding options are available to the farmer:

(*a*) he can ration the animals at maintenance levels and produce only a small weight gain over the Winter or

(*b*) he can fully feed the animals on silage to produce some additional weight gain over the Winter.

Because the relationship between feed intake and gain is assumed to be linear, intermediate levels of feeding are not relevant. The farmer should feed at one extreme or the other (i.e. full feeding or feeding for maintenance). We ignore feeding at sub-maintenance levels.

The most profitable feeding level under the above conditions can be determined from the following formula, the derivation of which is described in Appendix B.

(6) $\pi = P_2(s - M/G) + W_1(P_2 - P_1) - d + Q(P_2/G - c)$*

where π=Gross margin per animal (£);

W_1=Initial weight (cwt.);

s=Weight gain due to maintenance (cwt.);

P_1=Initial price (£ per cwt.);

P_2=Final price (£ per cwt.);

M=Amount of feed required per animal for maintenance (tons);

G=Amount of feed required per cwt. gain (tons);

Q=Total amount of feed per animal;

c=Cost per ton of feed (£);

d=Costs other than feed per animal (£).

If we let $P_2(s - M/G) + W_1(P_2 - P_1) - d = a$ and $(P_2/G - c) = b$

(6) can be written as

(7) $\pi = a + Qb$.

From (7) it can be seen that if "*b*" is positive ($b > O$) maximum Q gives maximum gross margin per animal. Now since $b = (P_2/G - c)$ "*b*" is positive whenever P_2/G is greater than "*c*" (i.e. when the selling price per cwt. (£) divided by the number of tons of feed per cwt. gain, is greater than the cost per ton of feed (£)), it follows that in this situation the farmer should plan to fully feed the animals over the Winter. On the other hand if "*b*" is negative ($b < 0$) minimum Q (i.e. Q=M) gives maximum profit.

[11]The writer is indebted to Mr. Andrew Conway of An Taluntais for suggesting this formulation.

Hence if the cost of feed in £ per ton is greater than the expected P_2/G ratio the farmer should aim to feed at maintenance levels. It should be kept in mind that "maximisation" in this context may mean "minimisation" of loss.

We can summarise the above statements by saying that where cattle is the limiting factor in production, the decision to feed fully or at maintenance levels depends on the selling price of cattle and on the cost per ton of feed. This contrasts with the previous case (limited feed) where the cost of feed did not enter the equation and where the level of feeding depended on the initial/final cattle price ratio. Though in the present case the level of feeding is not dependent on this ratio, changes in cattle prices over the feeding period are very important determinants of real profit.

It can be seen from equation (7) above that the level of the gross margin depends not alone on the magnitude of "*b*" but also on that of "*a*". Now since $a = P_2 (s - M/G) + W_1(P_2 - P_1) - d$ it is at once obvious that if other things are held constant the greater the price rise $(P_2 - P_1)$ the greater the value of "*a*". Similarly other things being equal the greater the weight gain of the animal (s) over the feeding period the greater the value of "*a*" also. The magnitude of the M/G ratio affects the value of "*a*" in the opposite direction. Since this ratio has a negative sign the greater its value the lower the value of "*a*". Similarly for "*d*" which also has a negative sign.

For normal values of the variables concerned the value of "*a*" tends to be negative, hence a positive value for "*b*" is necessary if the enterprise is to be profitable. Now since the animals should be fully fed whenever "*b*" is positive and fed at maintenance levels whenever "*b*" is negative it follows that as in the previous case (limited feed) full feeding of animals is normally the most profitable course. Feeding at maintenance levels will seldom increase profits and normally should be only undertaken in order to reduce losses.

November-April feeding

In the above examples we have for simplicity examined the economics of feeding cattle from November to March. As there is usually a further rise in prices between March and April, selling in the latter month may be the most profitable system under certain conditions. The figures in Table 9 show outputs from these two systems.

When preparing the figures in this table it was assumed that cattle of about 6½ cwt. are purchased in November and fed on aftermath for a period of about 4 weeks during which time they make a weight gain of about 1 lb. per day. In mid-December the cattle are housed and fully fed on silage so as to

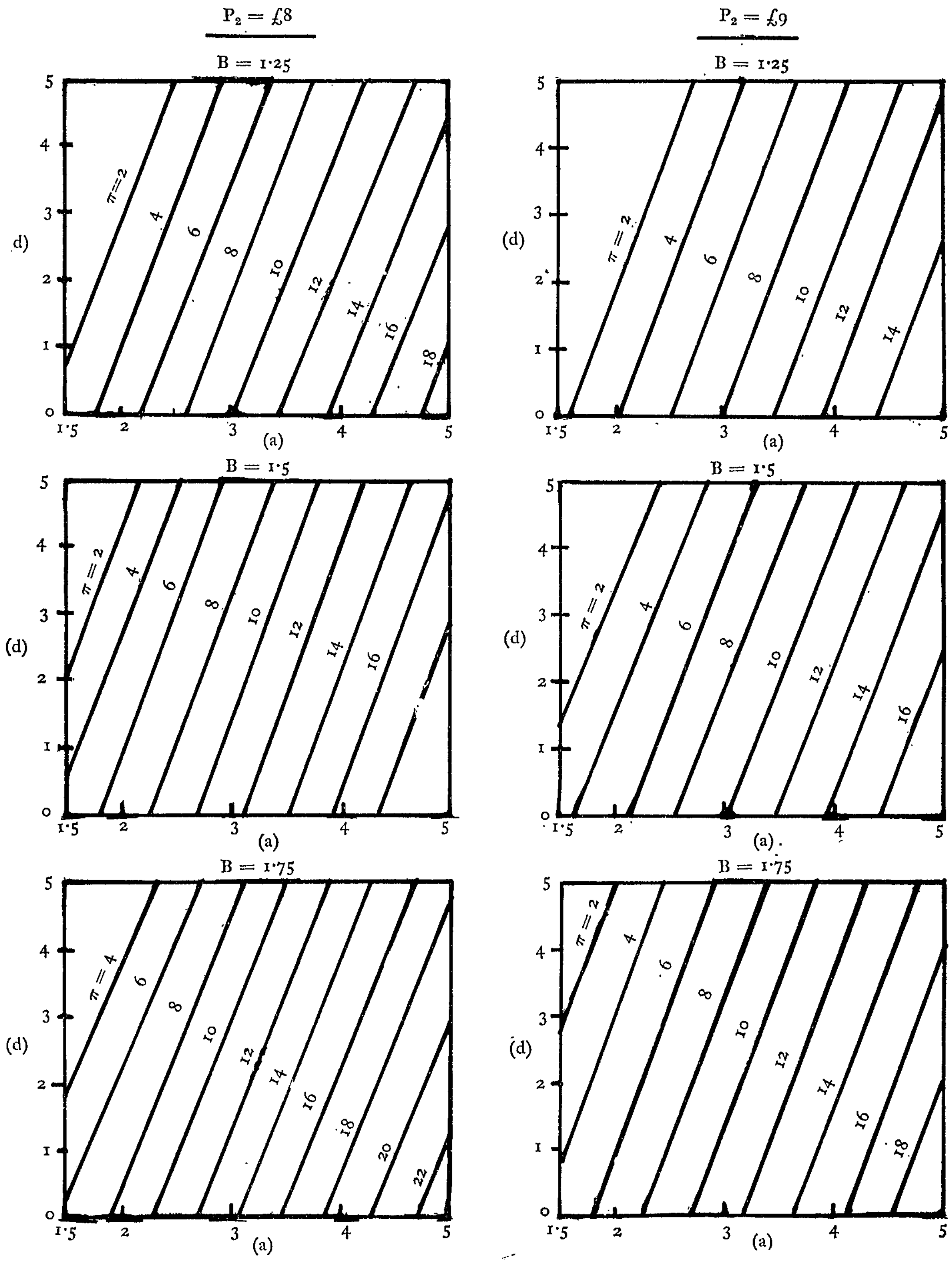
FIGURE 7: GRAPHS SHOWING GROSS MARGINS FROM WINTER FEEDING OF CATTLE ASSOCIATED WITH DIFFERENT COSTS AND SELLING PRICES: (Initial weight = $6\frac{1}{2}$ cwt: Silage consumption = $4\frac{1}{2}$ tons)

π = Gross margin per animal (£): c = Cost of silage (£ per ton)

B = (P_2-P_1) = Price rise over feeding period (£ per cwt.)

d = Other variable costs per animal (£)

G = Amount of silage required per cwt. gain above maintenance (tons)



P_2/G— c =(a) (£)

continue to make a daily gain of about 1 lb. Cattle sold in March were assumed to eat about 3½ tons of silage each and make weight gains of something over 1 cwt. Those sold in April were assumed to eat about 4½ tons of silage and make weight gains of about 1¼ cwt. between purchase and sale. It was assumed also that the yield of silage is 11 tons per acre from two cuts and that the November/December grazing is provided by the silage aftermath.[4]

When judged on a per animal basis the figures in Table 9 show that April selling gave the highest output in the years under review. Judged on a per acre basis on the other hand selling in March gave the highest output in all years. This might give the impression that if cattle is the limiting factor April selling is the most profitable system whereas if feed is the limit on production, March selling is the most profitable under the feed/weight gain relationship assumed.

TABLE 9: OUTPUT PER ANIMAL AND PER ACRE FROM CATTLE PURCHASED IN NOVEMBER AND SOLD IN MARCH AND APRIL 1963 — 1967

Year	Output per Animal		Output per Acre	
	Selling Date		Selling Date	
	March	April	March	April
1963–64 ..	20	24	63	59
1964–65 ..	19	23	60	56
1965–66 ..	20	23	63	56
1966–67 ..	24	28	75	68
1967–68 ..	24	29	75	71

However figures for output tend to be somewhat misleading in this context. For a given quantity of feed more cattle would be required if the animals are sold in March rather than in April and since each extra animal adds to costs, April selling may be the most profitable in all cases. In practice, farmers sell off the fatter cattle in March and carry the thinner ones until April which seems to be a sensible arrangement.

Comparison of winter feeding with summer grazing

On the basis of the various output figures already given, the cost of making silage and other costs would have to be very high before summer grazing would be more profitable than winter feeding in most years. That silage making costs are not excessive may be gathered from the following estimates.

[4]Based on data given by Behan, M. J., "Economics of Intensive Grassland Production on a Co. Meath Farm". Unpublished M.Agr.Sc. Thesis—Library University College, Earlsfort Tce., Dublin 1966.

In 1965 and 1966 the contract price for silage making throughout Ireland was in the region of 16s. per ton of grass ensiled. This payment covers the cost of cutting, carting and loading the grass on to the silo. About 5 tons of grass would have to be ensiled in order to make 4½ tons of silage so that the contract work for this amount of silage would cost about £4. If £1 per 4½ tons of silage is allowed for nitrogenous fertiliser to force on the grass and a further 10s. for other costs, the total variable costs over that of grazing is about £5 10s., or about £1 5s. per ton. Therefore if feed costs were the only consideration it would appear that the farmer who can organise properly the making of good silage is likely to do much better from winter feeding than from summer grazing. Not all farmers, of course, have the ability to make good silage and indeed a high proportion of the silage made is of very poor quality, some of it having a very high moisture content and being very unpalatable. Silage such as this is expensive at any price.

The provision of feed is, of course, not the only cost associated with winter feeding of cattle. Housing or feeding yards have also to be provided, since good pastures cut up badly in Winter and on such land outdoor feeding is impossible. If a conventional self feed system is used the capital costs less State grants are in the region of £22 per animal. This can amount to a substantial investment on large cattle farms and is probably the most serious deterrent to winter feeding. For farmers, however, who have dry land on which cattle can be kept outdoors, winter feeding on good silage is likely to be more profitable than summer grazing.

If actual or estimated output and cost figures are available the relative profitability of winter feeding and summer grazing can be determined fairly exactly from the graphs in Figure 7 which have been prepared from equation 6 above. These graphs show the gross profit per animal which can be obtained over a winter feeding period of 4½ months (Nov. to April) for different selling prices, price changes, feed and other costs. In preparing the graphs the initial weight of the cattle was taken as 6½ cwt. M/G was assumed to be 2·0 and Q was taken as 4½ tons. Animal scientists of course should have little difficulty in preparing similar graphs for other classes of cattle consuming different quantities of feed in different time periods.

A few examples will show how the graphs can be used.

Example 1. Suppose that in Spring a farmer who has a self-feed silage unit available wishes to decide whether he should graze his pastures during the Summer or conserve them as silage for the winter feeding of 6½ cwt. cattle, consuming 4½ tons each.

He expects to make good silage, $1\frac{1}{2}$ tons of which will produce 1 cwt. gain above maintenance. Total weight gain over the feeding period of $4\frac{1}{2}$ months is expected to be $1\frac{1}{2}$ cwt. He estimates that the selling price of the cattle in Spring will be £8 per cwt., that the price rise over the Winter will be £1·5 per cwt. and that the variable cost of making silage is £1·25 per ton. In estimating the latter cost, the basic fertilisers applied (regardless of whether the land was cut for silage or grazed) should be treated as a fixed cost and only the extra fertiliser applied for silage included. The farmer also estimates that the variable cost (other than feed) of winter feeding is £1·5 per animal. This does not include a figure for depreciation of the self-feed system since this is also a fixed cost. Interest on capital invested in the cattle should only be included if it is expected that the total of this will be different from the total interest payments on summer grazed cattle (i.e. if the total interest payment is to be the same regardless of the system adopted it may be left out of the reckoning). In practice total interest payment for summer and winter cattle are likely to be much the same. In Summer the farmer has a small number of cattle for a long period whereas in Winter he has a larger number for a shorter period.

The farmer's first exercise is to calculate the $(P_2/G-c)$ value which in this case is $(8/1\frac{1}{2})-1{\cdot}25=$ 4·1 approximately. Going now to the middle graph on the left hand side of Figure 7 he reads up from the 4·1 point on the horizontal axis and across from the 1·5 point on the vertical (other variable costs) axis. These points meet between the £14 and the £16 gross margin line and so he can say that under those conditions his gross margin per animal from winter feeding will be about £15 or about £37 per acre, assuming a yield of 11 tons of silage per acre. The farmer can now compare these returns with his expected gross margin per animal and per acre from summer grazing and make his decisions accordingly. In making the per acre comparison he will have to estimate the carrying capacity of the land when grazed over the Summer under his own system of management. He may be able to do this on the basis of experience or he may have to consult an animal nutrition expert.

In estimating costs for the grazing system the farmer should ignore the cost of fertiliser which is treated as being fixed, and interest charges if they were left out of the reckoning in estimating winter feed costs.

As a general point it can be said however that for all normal grazing outputs and costs the above winter feeding system would be a highly attractive proposition in comparison with summer grazing. (See section "Buying in Spring and selling in Autumn").

Example 2. In Example 1 the farmer estimated that he could make good silage giving a weight gain of 1 cwt. above maintenance from $1\frac{1}{2}$ tons. In this example we assume that all other conditions are the same as in Example 1 but that the quality of the silage is not so good. Suppose the farmer estimates that stomach capacity is still $4\frac{1}{2}$ tons but that the total weight gain produced from this amount of silage will be only $\frac{3}{4}$ cwt. (i.e. $\frac{1}{2}$ cwt. due to maintenance and $\frac{1}{4}$ cwt. above maintenance). The G value for this silage is calculated as follows:—

$$M+G\left(\tfrac{1}{4}\right)=4\tfrac{1}{2}$$

assume $M/G=2{\cdot}0$

$$\therefore\ G=2{\cdot}0$$

The $(P/G-c)$ value is now 2·75 (assuming silage making costs are the same as in Example 1).

Reading from the same graph as in the previous case it can be seen that gross profit per animal is now only about £9 or about £22 from an acre yielding 11 tons of silage. This system therefore is not nearly as attractive as the previous one but is still likely to be more profitable than summer grazing in most years.

Example 3. Suppose that conditions are exactly the same as in Example 1 except that housing or silos are not available. The farmer wishes to determine if it would be profitable for him to erect a self-feed silage unit so as to change over from summer grazing to winter feeding. His planning horizon is 15 years (i.e. the buildings must pay for themselves over a period of 15 years otherwise he is not prepared to make the change). He estimates that the cost of the self-feed system less State grants is £22 per animal. When this is amortised over 15 years at 7 per cent. per annum the annual cost is £2·4. This added on to the "*d*" value in Example 1 gives a figure of £3·9 and the same graph as that previously used shows that the gross margin per animal is now a little over £12 or £29 per acre (assuming 11 tons of silage per acre). On the basis of these figures the investment in buildings is likely to be justified. If however conditions are the same as those described in Example 2 (poor silage) and the depreciation of housing has to be included as a cost, the gross margins per animal and per acre are only about £6 and £15 respectively. In these circumstances the erection of housing for winter feeding is not likely to be a very economic proposition. These examples show that the quality of the silage is an important determinant of profits from wintering of cattle and it would appear that the farmer who is not a good silage-maker should be careful about erecting expensive buildings for winter feeding.

TABLE 10: WEIGHT GAINS AND OUTPUTS FOR CATTLE PURCHASED IN NOVEMBER AND SOLD IN JUNE IN DIFFERENT YEARS

Month	Weight	Year							
		1963–64		1964–65		1965–66		1966–67	
	cwt.	Price	Value	Price	Value	Price	Value	Price	Value
					£				
November ..	6·50	6·00	39·0	7·65	49·7	6·95	45·2	5·50	35·8
December ..	6·80	6·00	40·8	7·68	52·2	6·95	47·3	5·85	39·8
January ..	7·10	6·75	47·9	8·20	58·2	7·40	52·5	6·40	45·4
February ..	7·40	7·22	53·4	8·68	64·2	7·66	56·7	7·08	52·4
March ..	7·70	7·63	58·8	8·90	68·5	8·48	65·3	7·71	59·4
April	8·00	7·90	63·2	9·10	72·8	8·50	68·0	8·00	64·0
May	8·75	8·10	70·9	8·61	75·3	8·60	75·3	7·82	68·4
June	9·50	7·80	74·1	8·25	78·4	8·20	77·9	7·36	69·9

Buying in November and selling in June

Buying in November and selling in June is a system very often recommended by agricultural experts. The usual recommendation is that the animals be fully fed on silage over the Winter as indicated in the previous section. In mid-April they are put on to well manured pasture until mid-June when they are sold. If good silage is available cattle purchased at 6½ cwt. in November should weigh about 8 cwt. in mid-April and they should gain a further 1½ cwt. over the grazing period to reach about 9½ cwt. at selling time.[75]

Monthly weight gains and outputs for bullocks fed in this way in different years are shown in Table 10.

As can be seen from this table there was an increase each month in the output value of the cattle in every year though the returns in the period April to June are much lower than in the period November to April as shown in Table 11.

TABLE 11: OUTPUT PER ANIMAL AND PER ACRE IN DIFFERENT PERIODS IN DIFFERENT YEARS (£)

	Per Animal			Per Acre	
	Nov./ April	April/ June	Nov./ June	Nov./ April	Nov./ June*
1963/64	24	11	35	59	53
1964/65	23	6	29	56	44
1965/66	23	10	33	56	50
1966/67	28	6	34	68	52

*For method of calculating stocking rate per acre for the Nov./June period see Appendix B.

This table shows that at the weight gains postulated the output increase between November and April in the four years concerned was £23 per animal in 1964/65 and 1965/66, £24 in 1963/64 and £28 in 1966/67. The output gain between April and June varied from £11 per head in 1963/64 to £6 in 1964/65 and 1966/67. The output per acre in the period November/April which is based on a yield of 11 tons of silage per acre varied from £56 in 1964/65 and 1965/66 to £68 in 1966/67. As can be seen the output per acre from keeping cattle from November to June was less in each year (and considerably so in 1964/65) than that from a November to April feeding period. Hence at the weight gains postulated higher outputs are likely to be obtained by cutting all the grass for silage and feeding it to cattle in the period November to April than by grazing some of it from April to June. As stated above however, output figures tend to be misleading in this respect. If all grass is cut for silage and fed over the winter period, costs are much higher than if some of the grass is grazed by animals. In the former case more animals would be required for the shorter feeding period and hence greater marketing expenses and other costs. More housing space would also be required which is a most formidable barrier and of course there is also the additional cost of ensiling all the grass compared with feeding some of it as grazing.*

The break-even level of profitability per acre from November/April and November/June feeding can be determined from the following formula:

$$(8)\quad R_a[P_aW_a - P_1W_1 - cQ - d_a] = R_j[P_jW_j - P_1W_1 - cQ - d_a - d_s]$$

where

R_a=the stocking rate per acre for cattle fed completely on silage from November to April and where all grass is cut for silage, i.e.,

$$R_a = \frac{\text{Total production of silage per acre}}{\text{Amount of silage consumed per animal}}$$

R_j=the stocking rate per acre for cattle fed on silage from November/April and on pasture from April to June, calculated as shown in Appendix B.

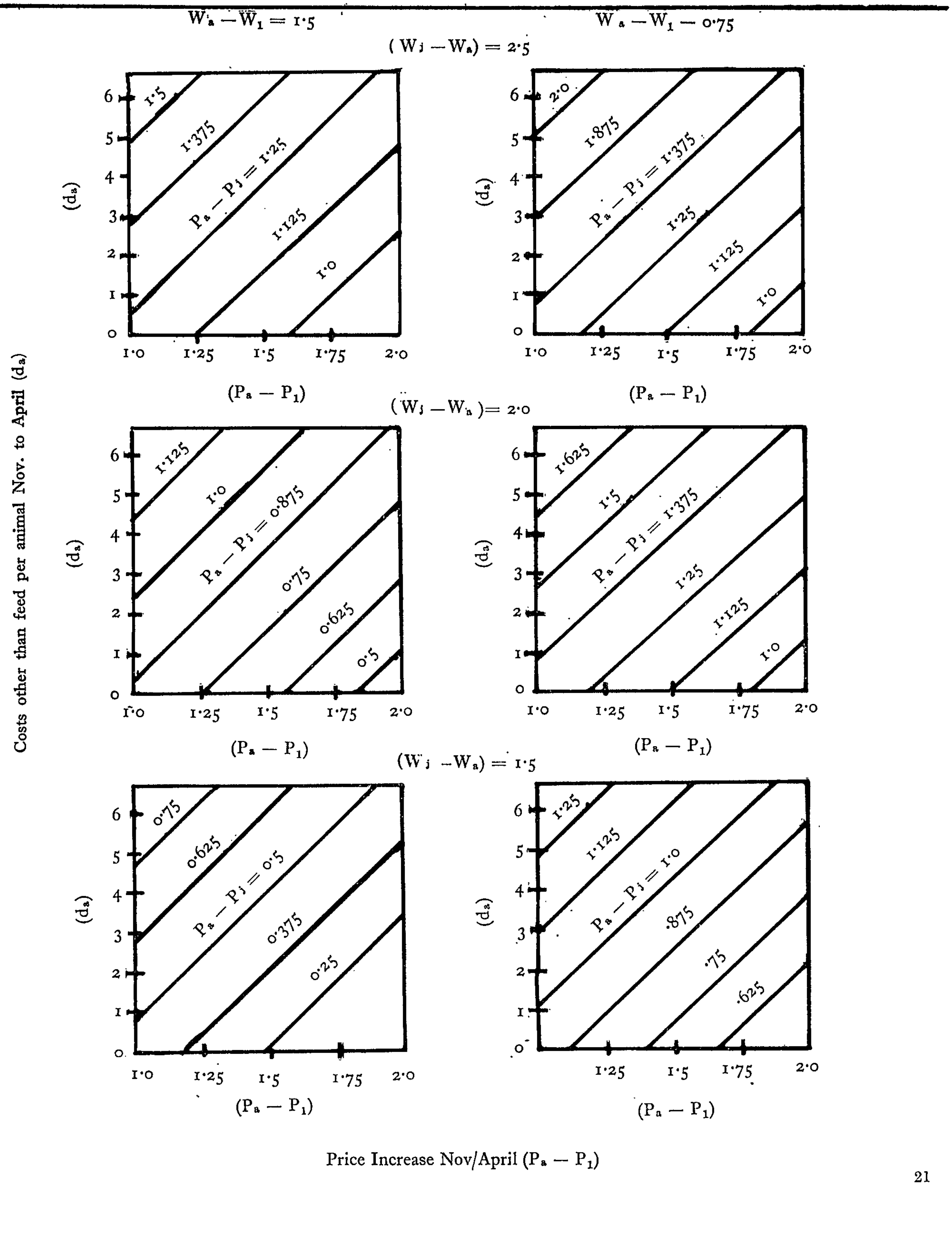
P_j=Price per cwt. of cattle sold in June (£)

[75]See Behan *op. cit.*

*Higher capital investments would also be required for the larger number of animals but interest payments would not necessarily be higher because of the shorter feeding period.

FIGURE 8: GRAPHS FOR ASSESSING BREAK-EVEN PROFITABILITY PER ACRE FROM NOV/APRIL AND NOV/ JUNE CATTLE FEEDING

$P_a = £8{\cdot}5$; $Q = 4\frac{1}{2}$ tons; $c = £1{\cdot}25$;
$W_1 = 6{\cdot}5$ cwt; $\frac{R_a}{R_1} - 1 = 0{\cdot}6$; $ds = £0{\cdot}25$



P_a=Price per cwt. of cattle sold in April (£)

P_1=Purchase price per cwt. of cattle purchased in November (£)

W_j=Weight per animal of cattle in June (cwt.)

W_a=Weight per animal of cattle in April (cwt.)

W_1=Initial weight per animal (cwt.)

Q=Amount of silage consumed per animal, November to April (tons)

c=Variable cost per ton of making silage (£)

d_a=Variable costs other than feed per animal of cattle sold in April (£)

d_s=Variable costs per animal other than feed, April to June (£)

The derivation of formula (8) is self-explanatory. The expression on the left hand side is the gross margin per acre from cattle sold in April while that on the right is the gross margin per acre from cattle fed on silage over the Winter and on grazing from April to June.

Formula (8) is not very suitable for analytical purposes but by manipulation it can be written as (9) which is more suitable for these purposes.

$$(9) \quad \left(\frac{R_a}{R_j}-1\right)[P_a(W_a-W_1)+W_1(P_a-P_1)-cQ-d_a]=P_j(W_j-W_a)-W_a(P_a-P_j)-d_s$$

If the farmer has some idea of his costs and weight gains in the different periods, and can estimate per acre stocking rates for both systems this formula can be used to determine the most profitable system for different classes of cattle under different price conditions. The same assessment can also be made for certain given conditions using Figure 8. In preparing the graphs in this figure it was assumed that P_a=£8·5; Q=4½ tons; c=£1·25; W_1=6·5 cwt., $[(R_a/R_j)-1]$=0·6 and d_s=£0·25.

Because of all the variables involved and of the magnitudes taken for the terms which were assumed constant it is difficult to make any simple general statement from a study of Figure 8. However, without going into any great detail the following statement appears to be justified:—

1. The weight gain from April to June is (as indeed one would expect) a very important determinant of whether cattle should be sold in April or put on to pasture until June. When the weight gain per animal over the grazing period is 2·5 cwt. it can be seen from the two upper graphs that very high price declines would have to occur before summer grazing would be unjustified. This is especially true where cattle make low gains over the winter (i.e. top right-hand graph).

On the other hand if the gain over the grazing period is low (say only 1·5 cwt. per animal) the situation is different. In this case unless wintering costs are very high and winter price rises very low a small price decline from April to June makes spring grazing of well-wintered cattle uneconomic, relative to sale in April (see bottom left-hand graph). Hence the farmer on cold late land who can make good silage might find it more economical to adopt the November–April feeding system in preference to the other, particularly if housing costs are not too high.

For the farmer who is a poor silage maker and who obtains low gains over the Winter, June selling is likely to be the most economical system in all cases. The bottom right-hand graph shows that even for low weight gains from grazing, higher than normal price drops would have to occur before grazing would be uneconomic relative to winter feeding.

Feeding grain along with hay or silage

The decision to feed grain during Winter in addition to roughage (hay or silage) depends on many factors, the principal ones being the quality of the roughage, the expected selling price of beef, the cost of the different feeds, and the rates at which they substitute for one another. If the roughage is of poor quality, it may be essential to supplement it with some grain, otherwise the cattle may become emaciated or even die. The feeding of grain in this case will at worst reduce losses and will increase profits if the beef/grain price ratio is favourable. If the roughage is of good quality, the decision to feed grain is more difficult and special technical input-output data are required in this case. Such data can only be obtained from specially designed controlled experiments and up to the middle of the 1960's very few of such experiments had been carried out anywhere in the world. Professor Heady and his colleagues at Iowa State University have done some work on the subject but as conditions in the U.S.A. are altogether different from those obtaining in Europe, the results are not applicable to Irish conditions.

The position however is improving. It is understood that experiments are in progress in An Foras Talúntais which may yield results suitable for such analysis. Some of the available European data though inadequate in many respects have been reworked and have yielded results which can be used in a rough way to determine the most economic level of feeding. The results of one such experiment at Liscombe in England have been analysed by Godsell and Preston[6] who have developed a function

[6]Godsell, T. E. and Preston, T.R.—Co-operation between Research in Agricultural Natural Sciences and Agricultural Economics—Report of 1963 Seminar—O.E.C.D. Document No. 65, Paris 1964.

Figure 9: AMOUNTS OF BARLEY PER DAY WHICH SHOULD BE FED TO BULLOCKS DURING WINTER FOR DIFFERENT SELLING PRICES OF CATTLE (S.P.) AND COST PRICES OF BARLEY AND SILAGE

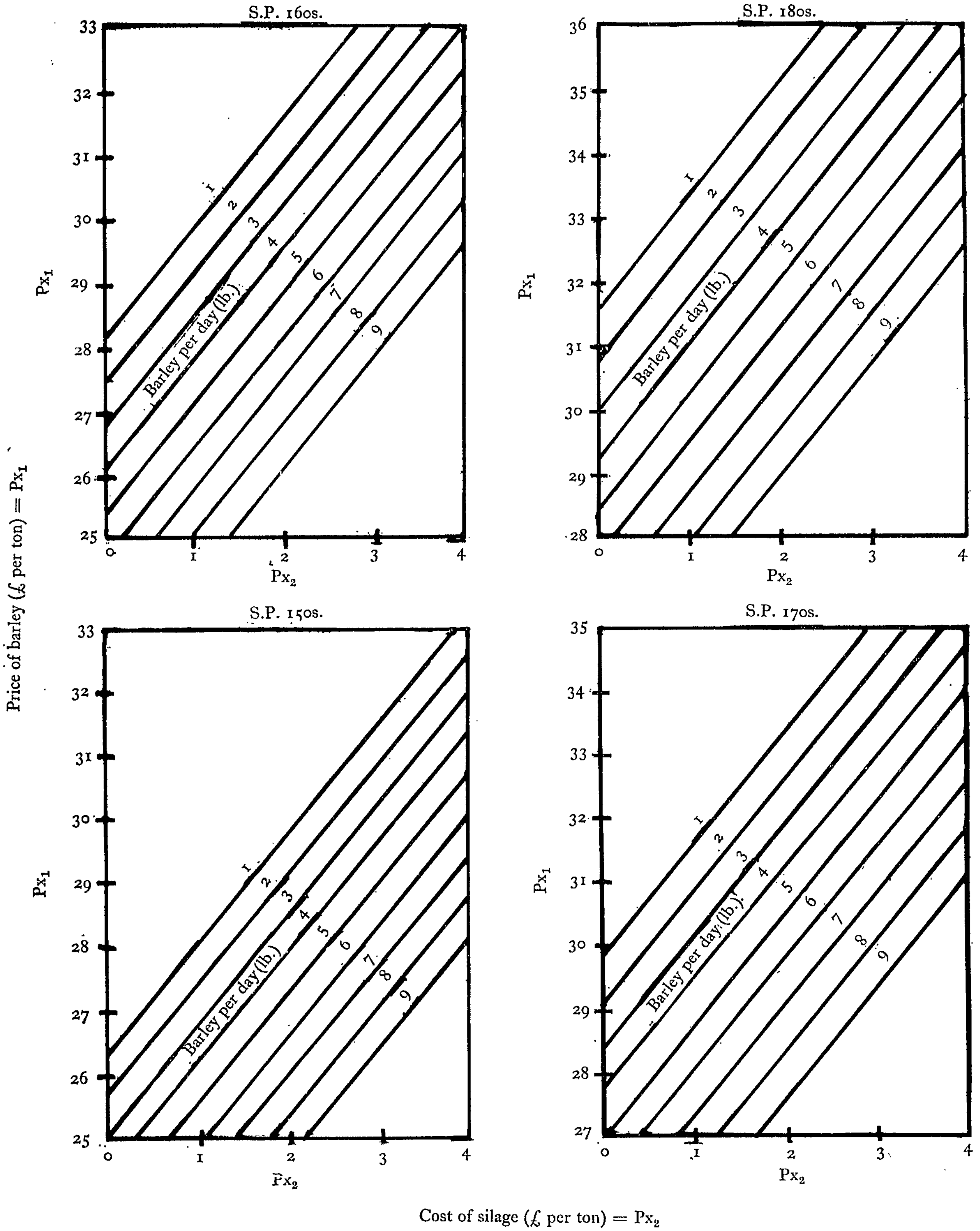


TABLE 12: MOST PROFITABLE LEVEL OF FEEDING 4–7 CWT. BULLOCKS IN WINTER (113 DAYS) ON GOOD SILAGE AND BARLEY AT DIFFERENT BEEF/SILAGE AND BEEF/BARLEY PRICE RATIOS

Beef/silage price ratio	Beef/barley Price ratio: 5·0/1 Amounts fed (lb.) silage	5·0/1 Amounts fed (lb.) barley	5·0/1 Weight gain (lb.)	5·25/1 Amounts fed (lb.) silage	5·25/1 Amounts fed (lb.) barley	5·25/1 Weight gain (lb.)	5·5/1 Amounts fed (lb.) silage	5·5/1 Amounts fed (lb.) barley	5·5/1 Weight gain (lb.)	5·75/1 Amounts fed (lb.) silage	5·75/1 Amounts fed (lb.) barley	5·75/1 Weight gain (lb.)	6·0/1 Amounts fed (lb.) silage	6·0/1 Amounts fed (lb.) barley	6·0/1 Weight gain (lb.)	6·25/1 Amounts fed (lb.) silage	6·25/1 Amounts fed (lb.) barley	6·25/1 Weight gain (lb.)
200/1							5,053	227	172	4,773	387	199	4,432	581	231	4,119	760	258
175/1							4,978	259	178	4,698	419	204	4,375	614	236	4,045	793	263
150/1				5,341	38	139	4,874	305	185	4,594	465	212	4,254	659	243	3,941	838	270
125/1				5,199	100	151	4,733	367	195	4,453	527	221	4,112	721	252	3,799	900	279
100/1				4,986	193	166	4,519	460	210	4,239	620	236	3,899	815	266	3,586	993	292
90/1	5,285		131	4,818	267	178	4,352	533	222	4,072	693	247	3,731	888	276	3,418	1,067	302
80/1	5,186	43	139	4,719	310	185	4,253	577	228	3,973	737	253	3,632	931	282			
70/1	4,994	127	153	4,527	394	198	4,060	661	241	3,780	821	265	3,440	1,015	293			
60/1	4,741	238	171	4,274	505	215	3,808	771	257	3,528	931	280						
50/1	4,386	393	196	3,719	660	238	3,452	927	278									

showing the production of beef from different combinations of grain and silage.

This function based on experiments carried out in the Winters of 1961–62 and 1962–63 relates to cattle of an initial weight of about 4 cwt., fed on barley and good silage (average dry matter 22·6 per cent.) over a period of 113 days. The feeding levels varied slightly between the two years but on average they were as follows:

Group I. All silage.

Group II. Silage plus 3 lbs. of barley per head per day.

Group III. Silage plus 6 lbs. of barley per head per day.

Group IV. Silage plus 9 lbs. of barley per head per day.

The mathematical function derived from the basic data and the method of obtaining the most profitable level of feeding from it are shown in Appendix B. This method has been used to derive the figures in Table 12, which show the quantities of silage and barley which should be fed over a period of 113 days in order to maximise the margin over feed per animal under different beef/silage and beef/barley price ratios. These ratios are obtained by dividing the selling price of one cwt. liveweight of beef by the price of one cwt. of silage and one cwt. of grain respectively.

Table 12 shows that—

(1) When the beef/barley price ratio is 5·0/1, all silage should be fed unless the beef/silage price ratio is 80/1 or less. Thus if barley can be sold or purchased for 28s. per cwt. and beef cattle sell for 140s. per cwt. all silage should be fed unless the variable cost per ton of making silage is 35s. per ton or more. At such a high price for silage, it pays to feed some grain along with the silage.

(2) When the beef/barley price ratio is 5·25/1, all silage should be fed unless the beef/silage price ratio is less than 150/1. For example, if barley costs 28s. per cwt. and beef is expected to sell for 147s. per cwt. all silage should be fed unless the cost of making silage is more than £1 per ton.

(3) When the beef/barley price ratio is 5·5/1 or greater it pays to feed some barley at all normal silage costs. Thus if barley costs 28s. per cwt. and beef is expected to sell for 154s. per cwt. or more, at least 2 lbs. of barley should be fed per beast per day. At this price for barley and an expected beef price of 164s. per cwt. at least 5 lbs. of barley per day should be fed.

In studying Table 12 it is necessary to convert the different ratios into prices of cattle and feed. To overcome this calculation problem, the graphs in Figure 9 have been prepared which show the amounts of barley to be fed for some actual selling prices of cattle and cost prices of barley and silage. Unfortunately because of space limitations these graphs only cover a few selected cattle selling prices but there is little difficulty in constructing similar graphs for other prices from equation 2 in section 5 of Appendix B.

It can be seen from Figure 9 that when the prices of beef and silage are high and barley costs are low very heavy levels of barley feeding are recommended. These recommendations must however be taken with caution as in some cases the margins from the "most profitable" feeding level are only slightly greater than those which would be obtained from silage feeding alone. These margins for certain selected prices of beef, barley and silage and for a constant beef price rise of £1 10s. per cwt. are shown in Table 13.

Reference to this table shows that when cattle sell for 160s. per cwt. or less there is little to be gained from barley feeding at all normal prices for barley and silage. At the low price of £28 per ton for barley and the high price of £2 per ton for silage the margin from the most profitable level of feeding at £11 17s. per animal is only 14s. per animal higher than that from all silage feeding. At these feed prices however when the cattle sell for 180s. per cwt. the extra margin from the most profitable level of feeding as against all silage feeding is £2 1s. per animal.

Taking the fairly realistic situation where the selling price of cattle in Spring is 180s. per cwt., the price of barley £30 per ton and the cost of silage £1 10s. per ton, the margin over feed from all silage feeding is £12 19s. and that from the most profitable level of feeding is £13 17s. giving a difference of only 18s. per animal from barley feeding. The most profitable level of barley feeding in this case is about 7 lbs. per day and the expected weight gain over the feeding period, about 254 lbs. It is doubtful if the difference of 18s. is sufficient to warrant such a heavy grain feeding programme particularly if the feeding involves extra labour.

One point should be kept in mind in this connection however. In calculating the differences in margins between the most profitable and the all silage feeding it was implicitly assumed that the same price per cwt. is obtained for cattle regardless of the method of feeding. This may not be so. The barley fed cattle may fetch higher prices per cwt. than the others because they have a better degree of finish, and if so the comparison may properly be between silage fed cattle selling for say 170s. per cwt. and barley fed animals selling for probably 180s. per cwt. If this is so the margins in favour of barley feeding will be higher than those shown in Table 13.

One other point should be noted in this connection however. If the quantity of silage for cattle feeding is fixed and the number of cattle which can be carried is variable more animals can be carried where a grain feeding programme is adopted than if silage alone is fed. Under these circumstances if profit per animal can be maintained or not too much reduced by feeding grain along with silage, the overall level of profit from the enterprise can be increased further by keeping extra cattle. Some idea may be obtained of the magnitude of this extra gain for a given set of conditions by reference to the last example, where the selling price of cattle was 180s. per cwt., the price rise over the feeding period 30s. per cwt., the cost of silage 30s. per ton and the cost of barley 30s. per cwt. Let us assume that under these conditions the amount of silage available is 47 tons and that there is no limit on the number of cattle which can be carried (other than that imposed by minimal silage requirements).

Now we find from the equations in Appendix B that at the most profitable level of feeding each animal consumes 4,076 lbs. of silage and 738 lbs. of grain. Under this feeding programme therefore the 47 tons of silage will carry about 26 cattle giving a margin over feed of £13 17s. per head (Table 13) amounting to a total margin of £360 from 26 cattle. If, however, the cattle are fed on silage alone, each consumes about 5,285 lbs. (see Table 12) and gives a margin over feed of £12 19s. per head (Table 13). At this level of feeding the 47 tons of silage will carry 20 cattle giving a total margin from the enterprise of only £259. Hence under these conditions there is a substantial gain from spreading the silage over the larger number of cattle.

It should be kept in mind of course that this gain comes almost entirely from extra cattle rather than from more economical feeding of individual animals. The analysis does show however that if in Autumn a farmer finds himself scarce on silage in relation to the number of cattle he can keep, he should be loath to cut back on cattle numbers without first examining the economics of feeding grain along with the scarce silage so as to spread the latter over as many cattle as he can keep.

TABLE 13: MARGINS OVER FEED COSTS FOR MOST PROFITABLE LEVEL OF BARLEY AND SILAGE FEEDING AND FOR ALL SILAGE FEEDING AT DIFFERENT PRICES FOR CATTLE, BARLEY AND SILAGE. (Initial weight of cattle 4 cwt; Price rise over feeding period of 113 days, £1 10s. per cwt):

Price of barley £ per ton	All silage feeding				Most profitable level of feeding				Difference in margins between most profitable and all silage feeding*			
	Beef Selling prices per cwt.											
	150s.	160s.	170s.	180s.	150s.	160s.	170s.	180s.	150s.	160s.	170s.	180s.
	Cost of Silage £1 per ton											
	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.
28	12 8	13 0	13 12	14 3	12 9	13 5	14 5	15 9	0 1	0 5	0 13	1 6
30	12 8	13 0	13 12	14 3	—	13 1	13 16	14 15	—	0 1	0 4	0 12
32	12 8	13 0	13 12	14 3	—	—	13 13	14 7	—	—	0 1	0 4
34	12 8	13 0	13 12	14 3	—	—	—	14 4	—	—	—	0 1
	Cost of silage £1 10s. per ton											
28	11 5	11 16	12 8	12 19	11 7	12 5	13 7	14 12	0 2	0 9	0 19	1 13
30	11 5	11 16	12 8	12 19	—	11 18	12 16	13 17	—	0 2	0 8	0 18
32	11 5	11 16	12 8	12 19	—	—	12 10	13 6	—	—	0 2	0 7
34	11 5	11 16	12 8	12 19	—	—	—	13 1	—	—	—	0 2
	Cost of silage £2 per ton											
28	10 1	10 13	11 4	11 16	10 6	11 7	12 11	13 17	0 5	0 14	1 7	2 1
30	10 1	10 13	11 4	11 16	—	10 17	11 16	12 19	—	0 4	0 12	1 3
32	10 1	10 13	11 4	11 16	—	10 13	11 8	12 6	—	—	0 4	0 10
34	10 1	10 13	11 4	11 16	—	—	11 5	11 19	—	—	0 1	0 3

*Selling prices per cwt. of "all silage", and "silage and grain" fed cattle assumed to be the same.

APPENDIX A

AVERAGE PRICE PER CWT. OF BULLOCKS AND HEIFERS IN CERTAIN WEIGHT CLASSES AT LIVESTOCK AUCTION MARTS (Excluding Dublin)

Period	Bullocks					Heifers		
	6 and under 7 cwts.	7 and under 8 cwts.	8 and under 9 cwts.	9 and under 10 cwts.	10 and under 11 cwts.	6 and under 7 cwts.	7 and under 8 cwts.	8 and under 9 cwts.
	Per cwt.							
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1963	134 6	131 3	128 0	125 3	121 6	121 6	119 6	117 3
1964	156 0	151 6	148 3	145 3	144 0	144 3	141 6	139 3
1965	168 9	162 6	158 0	154 0	152 6	154 9	151 6	147 9
1966	150 0	146 0	142 9	140 6	138 6	136 6	135 0	132 6
1967	141 0	142 9	144 6	145 9	146 6	132 0	134 6	135 6
1963:								
January	124 3	123 3	121 6	120 3	119 9	114 9	116 9	117 0
February	129 0	127 0	124 3	121 6	117 6	117 9	116 3	116 9
March	138 6	134 9	130 6	125 0	120 9	123 6	121 3	117 6
April	141 9	138 9	132 9	129 3	122 9	128 0	126 0	122 6
May	144 9	140 6	137 6	133 3	129 3	131 9	130 3	125 6
June	141 9	137 6	135 6	131 6	128 9	127 0	125 0	121 0
July	141 3	136 6	135 6	132 9	129 3	127 3	125 3	122 6
August	137 0	133 6	131 3	130 0	127 6	123 0	121 6	120 6
September	128 9	125 3	123 9	123 3	120 9	114 9	116 3	114 9
October	125 6	123 3	120 3	119 6	117 6	112 9	112 6	112 3
November	120 6	119 0	116 9	114 6	113 6	111 3	110 0	109 6
December	120 6	119 3	118 9	115 9	116 0	111 6	113 3	113 6
1964:								
January	135 3	132 0	129 9	127 6	128 6	124 9	123 6	123 0
February	145 6	144 6	142 6	140 3	139 3	135 6	134 0	132 6
March	154 6	152 9	151 3	147 9	146 6	143 6	142 6	141 9
April	161 3	159 3	156 0	152 3	149 6	151 6	148 0	147 3
May	167 9	164 9	162 0	157 6	153 9	155 9	152 3	150 0
June	168 6	162 9	159 9	156 0	155 6	157 3	151 3	147 6
July	166 6	160 6	157 3	156 0	155 9	154 6	150 6	147 6
August	159 3	152 6	150 0	149 3	148 3	147 3	145 0	143 6
September	153 3	147 6	144 6	143 6	143 6	142 0	139 9	139 0
October	149 6	145 0	141 6	139 9	139 6	138 3	136 3	134 9
November	153 0	149 0	145 3	142 6	142 9	141 3	139 6	137 9
December	153 6	149 3	146 0	144 6	145 9	142 3	141 0	140 9
1965:								
January	166 6	162 6	159 0	158 6	160 6	154 9	154 0	153 0
February	177 9	173 6	169 6	165 9	164 6	164 6	160 6	157 6
March	182 6	178 0	174 0	169 3	165 9	168 9	162 9	158 9
April	192 0	185 6	180 9	174 6	170 6	176 0	171 3	168 6
May	184 9	178 6	173 3	168 0	165 6	169 6	167 0	164 6
June	176 9	171 0	167 6	165 0	164 6	164 0	160 6	157 6
July	173 6	167 3	164 6	163 0	161 9	158 0	155 3	153 3
August	159 3	156 3	155 9	156 9	156 3	147 9	147 9	146 6
September	149 3	146 6	146 0	147 6	148 0	141 6	141 3	141 0
October	142 6	141 0	139 6	139 0	139 6	132 3	135 0	134 0
November	139 0	138 0	136 6	137 6	137 6	128 3	130 9	130 9
December	139 0	138 6	138 6	138 9	140 6	129 0	134 0	135 6
1966:								
January	149 6	147 9	147 3	147 0	148 9	137 6	141 6	143 6
February	154 6	153 3	152 0	151 3	152 3	142 3	145 0	146 3
March	170 3	169 6	166 9	163 0	160 9	157 9	158 3	157 3
April	171 9	171 6	169 6	169 9	169 6	159 9	162 9	168 6
May	172 0	172 9	171 9	170 0	171 3	160 0	165 3	167 6
June	165 0	165 0	164 0	164 0	165 9	150 6	153 0	153 0
July	149 0	148 3	152 0	153 6	154 3	137 9	141 0	141 6
August	131 0	133 3	136 0	138 0	139 3	125 3	128 9	128 6
September	126 0	128 6	130 3	133 3	133 9	117 0	122 0	122 3
October	121 3	122 0	123 3	124 3	124 6	109 9	112 9	113 6
November	110 0	112 3	116 0	119 0	121 0	101 0	105 0	107 9
December	117 0	119 0	122 6	123 9	125 3	108 3	111 0	115 3
1967:								
January	128 0	130 3	132 9	135 0	136 6	117 0	121 0	123 6
February	139 9	141 6	143 6	144 6	146 0	129 0	133 6	134 9
March	151 6	154 3	155 9	156 9	156 6	142 6	144 9	146 3
April	157 9	161 0	162 0	162 6	163 0	148 0	151 0	153 6
May	151 6	153 0	156 6	158 3	161 0	143 0	148 0	149 9
June	136 9	139 9	143 3	147 3	148 9	131 6	136 0	136 3
July	129 0	135 6	137 6	138 6	139 0	124 9	128 3	126 6
August	131 6	135 3	139 0	140 9	141 0	123 6	127 0	128 6
September	135 6	137 3	141 3	144 0	145 0	125 6	129 3	131 0
October	133 3	135 9	138 6	140 6	142 3	121 9	125 6	127 9
November	139 6	141 6	143 3	146 3	147 9	127 6	131 6	135 6
December	146 9	148 0	149 3	153 6	158 9	138 3	144 6	147 0

Source: March issues of *Irish Statistical Bulletin*, C.S.O., Dublin.

APPENDIX B

1. Developing a formula for break-even gross margins under different stocking rates.

Let P_2 =selling price per cwt. (£)

,, a =price fall ∴ purchase price = P_2+a (£)

,, W_1=weight per head in Spring (initial weight).

,, x_n =gain in weight per head at rate of n animals per acre. (cwt.)

,, n =number of animals per acre

,, c =variable cost per animal other than fertilisers (£)

,, π =gross margin per acre (£)

$$\pi=n[P_2(W_1+x_n)-(P_2+a)W_1-c]$$

$$=n[P_2x_n-W_1a-c] \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

For $n=1 \quad \pi=P_2x_n-W_1a-c \quad \ldots\ldots\ldots\ldots (2)$

If (1)=(2)

$$n[P_2x_n-W_1a-c]=P_2x_n-W_1a-c$$

$$\text{Hence } x_n=\frac{1}{n}\left[\frac{(W_1a+c)(n-1)}{P_2}+x_1\right] \quad \ldots\ldots\ldots\ldots (3)$$

2. Developing a break-even price increase formula for storing or fattening cattle over winter where feed is the limiting factor.

Let Q =amount of feed available

M =amount of feed per animal required for maintenance in some given period (cwt.)

G =amount of feed required per cwt. gain (cwt.)

P_2 =selling price (£ per cwt.)

P_1 =purchase price (£ per cwt.)

B =price rise ∴ $P_1=(P_2-B)$

W_1=initial weight (cwt.)

W_2=final weight of animals fed at maintenance levels

s =weight gain for animals fed at maintenance levels (cwt.) [stores]; hence $s=W_2-W_1$

f =additional weight gain for fully fed animals (cwt.) [fats]

$$\left.\begin{aligned} n_s &= \text{number of stores} = Q/M \\ n_f &= \text{number of fats} = \frac{Q}{M+Gf} \end{aligned}\right\}$$

$$\frac{n_s}{n_f}=1+\frac{Gf}{M} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (a)$$

π =gross output (£) from a given quantity of silage (Q)

$$\pi=n_s[P_2(W_1+s)-(P_2-B)W_1] \text{ stores}$$

$$\pi=n_f[P_2(W_1+s+f)-(P_2-B)W_1] \text{ fats}$$

Hence for equal returns

$$n_s[P_2s+BW_1]=n_f[P_2s+P_2f+BW_1]$$

$$\frac{n_s}{n_f}=\frac{P_2s+P_2f+BW_1}{P_2s+BW_1}$$

Substituting for n_s/n_f from (a) above and simplifying we obtain:

$$\frac{B}{P_2}=\frac{M/G-s}{W_1}$$

$$\therefore \frac{P_2-P_1}{P_2}=\frac{M/G-(W_2-W_1)}{W_1}$$

which is the break-even formula given on page 14.

3. Developing a formula for determining profitability from Winter feeding where cattle is the limiting factor.

Using the same symbols as in 2 above, but letting Q= total feed per animal, π=gross margin per animal; c=cost per ton of feed and d=other variable costs per animal, the profit equation is

$$\pi=P_2[W_1+f+s]-[(P_2-B)W_1]-cQ-d$$

$$=P_2f+P_2s+BW_1-cQ-d$$

$$=P_2\left[\frac{Q-M}{G}\right]+P_2s+BW_1-cQ-d$$

$$=Q[P_2/G-c]+P_2\left[s-\frac{M}{G}\right]BW_1-d$$

$$=P_2\left[s-\frac{M}{G}\right]+W_1(P_2-P_1)-d+Q(P_2/G-c)$$

4. Calculating stocking rates for cattle fed on silage during Winter and grazed until June.

Under this system silage will have to be taken entirely from some fields, while the remaining fields will have to be used for both grazing and silage.

Let F =yield of silage per acre from whole year's growth (tons)

S =yield of silage per acre from post June growth (tons)

Q =amount of silage consumed per animal over winter (tons)

n =number of cattle per acre from April to June

x =proportion of one acre cut entirely for silage ∴ area partly grazed is $(1-x)$

R =average stocking rate.

Total yield of silage per acre $= Fx + S(1-x)$

Number of cattle which can be carried on this amount of silage $= \frac{Fx+S(1-x)}{Q}$

Number of cattle grazed $= n(1-x)$

Since number of cattle wintered and grazed are the same

$$n(1-x) = \frac{Fx+S(1-x)}{Q} = R$$

$$x = \frac{nQ-S}{F+nQ-S}$$

$$R = n(1-x) = \frac{nF}{F+nQ-S}$$

Letting $F=11$, $S=5\frac{1}{2}$, $Q=4\frac{1}{2}$ and $n=2$

average stocking rate $R = n(1-x) = 1{\cdot}518$

5. Most profitable level of feeding grain and silage.

The mathematical function derived by Godsell and Preston from the Liscombe experiments (described in the text) was a quadratic of the following form

$$(1)\quad Y = -4{\cdot}388 + 0{\cdot}570X_1 + 0{\cdot}223X_2 - 0{\cdot}008X_1^2 - 0{\cdot}002X_2^2 - 0{\cdot}007X_1X_2$$

where

Y = Liveweight gain (100 lb.) in a period of 113 days

X_1 = Weight of barley fed (100 lb.) in same period

X_2 = Weight of silage fed (100 lb.) in same period.

The most profitable feeding level can be determined from this equation by taking partial derivatives of Y with respect to X_1 and X_2 setting these derivatives equal to the barley/beef and silage/beef price ratios respectively and solving for X_1 and X_2. To obtain a solution let us assume that beef cattle sell in Spring for 170s. per cwt., that barley costs 32s. per cwt., and that the cost of making silage is £1 10s. per ton, i.e. 1s. 6d. per cwt.

Taking partial derivatives of (1) and setting them equal to the feed/beef price ratios we obtain

$$(2)\quad \delta Y/\delta X_1 = 0{\cdot}570 - 0{\cdot}016X_1 - 0{\cdot}007X_2 = 32/170 = 0{\cdot}188$$

$$\delta Y/\delta X_2 = 0{\cdot}223 - 0{\cdot}004X_2 - 0{\cdot}007X_1 = 1{\cdot}5/170 = 0{\cdot}009$$

Solving these equations we get

$$X_1 = 1{\cdot}91 \text{ and } X_2 = 50{\cdot}22$$

Substituting these values into the production function (1) we obtain $Y = 1{\cdot}60$.

Hence for maximum profit over a period of 113 days the cattle should be fed 192 lb. of barley, 5,002 lb. of silage and for this level of feeding they should make a liveweight gain of 160 lb. In daily terms these figures represent about 2 lb. of barley, 44 lb. of silage and a liveweight gain of about $1\frac{1}{2}$ lb.

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