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Economic comparison of pasture based dairy calf-to-beef production systems under temperate grassland conditions

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ABSTRACT

With the abolition of EU milk quotas in 2015, the Irish dairy sector is positioning itself for substantial expansion which will result in an increase in calves from the dairy herd available for beef production. A wide range of beef cattle production systems are possible for these extra calves reflecting differences in breed, gender and finishing age. The Grange Dairy Beef Systems Model was used to simulate beef production from male and female calves born to Holstein-Friesian dairy cows bred to late maturing, early maturing and Holstein-Friesian sires and finished at different ages. The most profitable system was finishing steers at 28 months of age with the least profitable system being finishing male animals as bulls at 16 months of age. All systems were sensitive to beef, calf and concentrate price variations. The main implications from this study are that, irrespective of the system, maximising the proportion of grazed grass in the diet and the percentage of live weight gain from grass while also maintaining a high carcass output per hectare are the main drivers of profitability. Other issues such as land and labour charges, bonus schemes and variations in beef, calf and concentrate prices are important and can differ considerably depending on farm circumstances. Therefore, these issues need to be considered when deciding between different dairy calf-to-beef systems.

KEYWORDS: Bulls; dairy beef; grass based; heifers; simulation; steers

1. Introduction

The abolition of the European Union milk quota system in 2015 (European Commission, 2009) is expected to lead to an expansion of the dairy cow herd in Ireland (DAF, 2010) which will lead to an increase in the number of dairy origin calves available for beef production. The majority of dairy cows in Ireland are Holstein-Friesian (AIM, 2012) and are bred to Holstein-Friesian (FR) sires to produce replacements, in addition to early maturing (EM; Aberdeen Angus or Hereford) and late maturing (LM; e.g. Belgian Blue or Charolais) beef sires to produce crossbred progeny that are finished within dairy calf-to-beef production systems. In the case of these dairy calf-to-beef production systems, the different breeds that are produced differ in many aspects including feed intake, kill out proportion, carcass conformation and fat class. Late maturing animals have a higher kill out proportion and conformation score than EM animals which are greater again than FR animals (Keane and Drennan, 2009). At the same slaughter weight, early maturing animals have a higher fat class than FR animals which in turn are higher than LM animals (Keane and Moloney, 2010). These factors influence the market for which each of the breed types are suitable and therefore, the suitability of different production systems differs depending on the breed of the animal (Keane and Drennan, 2008). The Irish beef industry is estimated to export approximately 90% of total production (DAF, 2013). The United Kingdom is the largest market for Irish beef accounting for 52% of exports (the main market for dairy origin animals); 47% of Irish beef exports go to other European countries and 1% to international markets (Bord Bia, 2012).

There have been few models that have studied beef production systems using calves from the dairy herd (e.g. Kilpatrick and Steen, 1999; Bonesmo and Randby, 2010; Ashfield *et al.*, 2012a,b and 2013a,b,c). Feeding strategies were modelled by Bonesmo and Randby (2010) who found that feeding bulls high energy grass silage during the finishing period increased profitability. Kilpatrick and Steen (1999) developed a model that predicted the growth and carcass composition of a number of cattle breeds over a range of different feeds. However, these studies were only concerned with the finishing stage of the system. Ashfield *et al.* (2012a,b and 2013a,b,c) studied dairy calf-to-beef systems at a whole farm level, however, differences in input and output prices made comparisons between systems across studies difficult. The studies of Ashfield *et al.* (2012a,b and 2013a,b,c) quantified the economic performance of

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subsets of the total finishing options that are available to dairy calf-to-beef farmers and therefore, did not permit a comprehensive across production systems comparison. Furthermore, the studies of Ashfield *et al.* (2012a,b and 2013a,b,c) did not take into account the effects of bonus schemes, land or labour charges which, although contingent on specific farm circumstances, can have a considerable impact on farm profitability. Thus, it is apparent that the majority of beef system models have focussed mainly on finishing systems and there is a paucity of whole farm models of dairy calf-to-beef production systems looking at the range of breeds, genders and finishing ages that can be achieved from the range of animals produced from the dairy herd.

Therefore, the objective of this study is to compare the profitability of a wide range of dairy calf-to-beef systems in the context of differences in breed, gender and finishing age at constant input and output prices to determine the most profitable systems, the main drivers of profitability for these systems and the effect of bonus schemes, land and labour charges on the profitability of these systems.

2. Materials and methods

Model description

The Grange Dairy Beef Systems Model (GDBSM) is a whole farm model and thus, it integrates the various components of beef farming systems into a single framework. The model adopts a single year static approach and assumes that the system operates in a steady state condition. This facilitates the technical and economic evaluation of dairy calf-to-beef production systems. The model is described in detail by Ashfield *et al.* (2013a) and so is only summarised here. It is an empirical model that uses data from production research experiments, conducted primarily at the Animal and Grassland Research and Innovation Centre, Teagasc, Grange, to specify coefficients and production functions (e.g. grazed grass dry matter digestibility and energy content, live weight gain and the monthly proportion of grazed grass and grass silage in the diet).

In setting up each model run, the farm land area owned and the cattle production system choices (e.g. animal breed, gender and age at slaughter) must be specified. Production systems modelled are based on three breed groups which represent the progeny of Holstein-Friesian dairy cows which are bred to LM, EM and FR sires. Within these three breed groups, male cattle can be produced as bulls or steers. Heifer finishing options are also included for EM and LM progeny but not for FR since it is assumed that all of these progeny are retained as replacements for the dairy production system from which they were bred. The model incorporates a range of finishing ages for each breed/gender combination. Animals within each group, according to breed, gender and finishing age, are assumed to be homogenous and consequently the model excludes variability among animals within groups. The forage system in terms of inorganic nitrogen (N) applied to the grazing area and number of grass silage harvests (one or two) must also be specified. Inorganic N application rates for grass silage production are set according to Teagasc recommendations (Coulter and Lalor, 2008).

The model consists of four sub-models comprising farm systems, animal nutrition, feed supply and financial components. A schematic diagram of how the different components of the model interact is shown in Figure 1. The default operation of the model does not include imputed charges for the opportunity cost of owned land and unpaid family labour (including the farmer's own labour). Key outputs from the financial sub-model are the monthly and annual cash flow and annual profit and loss account. All costs and margins are presented per farm, hectare, livestock unit (LU, an animal aged 0 to 12 months is 0.3 LU, 13 to 24 months is 0.7 LU and 25+ months is 1 LU), animal unit (AU, one AU equals an animal from purchase at 1 week of age to leaving the farm for slaughter) and kilogram of carcass sold.

Scenarios

In Ireland, there are a large number of different beef systems for dairy origin animals due to the different breed, gender and finishing age combinations that can occur. The selection of systems analysed in the current study were informed by the previous studies of Ashfield *et al.* (2012a,b and 2013a,b,c) and those systems most common in Ireland. Despite the lower profitability of finishing FR bulls at 16 months of age it was included in the current analysis because indications from the market are that bulls less than 16 months of age at slaughter are preferred (Dawn Meats, 2011). Therefore, to investigate the profitability of dairy calf-to-beef systems across a wide range of breed, gender and finishing age combinations a number of scenarios were investigated.

- Holstein-Friesian males finished as steers at 24 (HS24) and 28 (HS28) months of age, or as bulls at 16 (HB16) and 19 (HB19) months of age.
- Late maturing males finished as steers at 24 (LS24) and 28 (LS28) months of age and as bulls at 16 (LB16) months of age. Late maturing heifers finished at 21 (LH21) months of age.
- Early maturing males finished as steers at 20 (ES20), 22 (ES22) and 28 (ES28) months of age. Early maturing heifers finished at 19 (EH19) months of age.

All FR animals were born at the start of February and LM and EM animals were born at the start of March because in Ireland the number of calves born to a dairy (FR) sire and beef (LM and EM) sire peaks in February and March, respectively, (AIM, 2012). The calf rearing phase was as described by Ashfield *et al.* (2013a) finishing at the end of April. The first summer grazing period (when animals were outdoors consuming grazed grass only) was from the start of May to the end of October. Animals then commenced their first winter feeding period (animals were indoors and consumed a diet of grass silage and concentrate) after which production systems diverged. The animals finished at 16 months of age (HB16 and LB16) consumed a diet of *ad libitum* concentrate and grass silage and remained on this diet until they were finished at the end of May and June, respectively. Other animals destined for later finishing commenced their second summer grazing period in March and ended in October except for EH19 animals which were finished, off grass, in

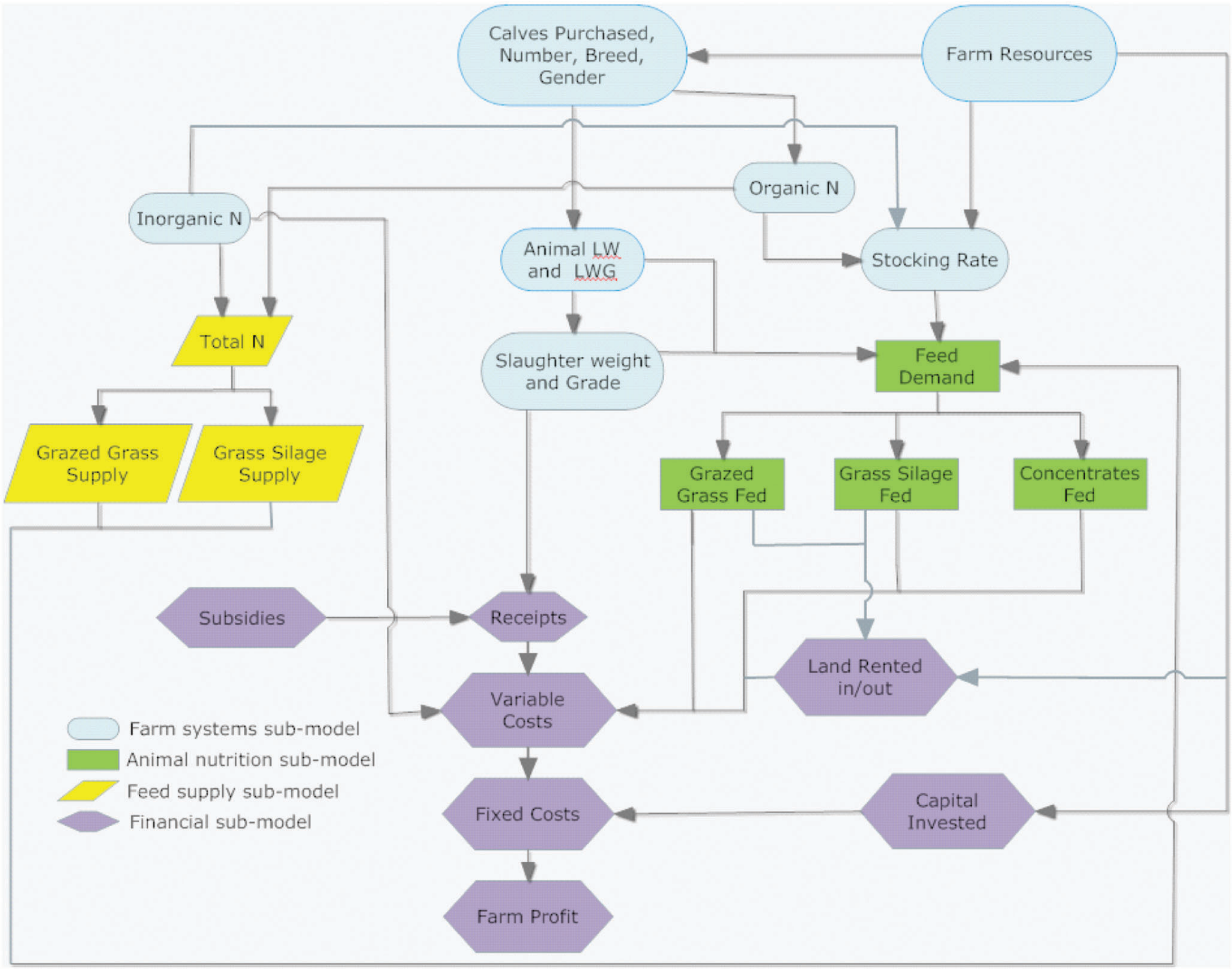

Figure 1: Schematic diagram of the Grange Dairy Beef Systems Model

September. In addition ES20 animals were finished off grass at the end of October. For EH19 and ES20, the finishing diet consisted of grazed grass and concentrates (receiving concentrate for the final 60 days). Older finished animals returned indoors for their second winter feeding period and consumed a diet of grass silage and concentrate. ES22, HS24 and LS24 were finished during their second winter feeding period at the end of December, January and February, respectively. Animals in the HS28, LS28 and ES28 systems returned outdoors for a third summer grazing period and were finished on a diet of grazed grass. HS28 animals were finished at the end of May with LS28 and ES28 animals finished at the end of June.

As the Nitrates Directive of the European Union (Directive 91/676/EEC) limits organic N output to 250 kg N ha^{-1} (DAF, 2008) stocking intensity was set below this limit (210 kg organic N ha^{-1}). This is the quantity of organic N excreted by animals on an annual basis with excretion rates of 65 kg for suckler cows and cattle greater than 24 months of age, 57 kg for cattle aged 13 to 24 months of age and 24 kg for cattle aged 0 to 12 months of age (DAF, 2008). Farm size was set at 50 hectares. Price and cost assumptions for all scenarios are shown in Table 1. All scenarios were subjected to sensitivity analysis with respect to beef, calf, concentrate and fertiliser prices. The live weight gains, slaughter weights, kill out proportions, carcass weights, conformation and fat class scores were taken from data produced at the Animal & Grassland Research and Innovation Centre, Teagasc, Grange and Johnstown Castle (Keane and Drennan, 2009; Keane *et al.*, 2009; Robert Prendiville, Teagasc; personal communication).

3. Results and discussion

Drivers of profitability

This paper compared a range of different dairy calf-to-beef production systems differing in breed, gender and finishing age. Table 2 presents the main physical results and Table 3 presents the main financial results for the systems investigated (unless otherwise stated the net profit does not include bonus scheme payments or a labour and land charge which are discussed separately later). The most profitable system was LS28 which had a very high proportion (70%) of grazed grass in the production system feed budget and the highest proportion of total life time live weight gain from grazed grass (81%). This finding is supported by Crosson *et al.* (2007) and Ashfield *et al.* (2013a) who found that the most profitable system had the highest proportion of grazed

Table 1: Prices used in the scenarios to determine the profitability of different dairy calf-to-beef systems[1]

Holstein-Friesian male calf price (€/ head)[1,2]	128
Late maturing male calf price (€/ head)[2]	355
Late maturing female calf price (€/head)[2]	335
Early maturing male calf price (€/ head)[2]	248
Early maturing female calf price (€/ head)[2]	248
Average annual beef price (R3 steer) (€/kg)[3]	434
Average annual beef price (R3 bull) (€/kg)[3]	427
Average annual beef price (R3 heifer) (€/kg)[3]	456
Calf concentrate (€/t)[4]	350
Yearling concentrate (€/t)[4]	300
Finisher concentrate (€/t)[4]	300
Milk replacer (€/t)[5]	2,100
Calcium ammonium nitrate (€/t)[6]	330
Urea (€/t)[6]	440
P & K compound fertiliser 0-10-20 (€/t)[6]	425
P & K compound fertiliser 0-7-30 (€/t)[6]	450

Notes: 1. At the time of writing (December 2013), €1=US$1.36, GBR£0.83
2. Irish Farmers Journal (IFJ) (2013a)
3. Bord Bia (2013a)
4. CSO (2013)
5. IFJ (2013b)
6. CSO (2012)

grass in the diet. Grazed grass is the cheapest feed available to Irish farmers (Finneran *et al*., 2012) and feed costs are one of the main drivers of profitability in beef production systems (Miller *et al*., 2001; Ramsey *et al*., 2005) and make up a large proportion of total variable costs (Ashfield *et al*., 2013a).

Therefore, those production systems with a higher proportion of grazed grass in the diet have lower costs of production. All systems studied take advantage of compensatory growth except the 16 month bull systems and compensatory growth has been shown to be advantageous by leading to increased live weight gain and reduced feed costs (Ashfield *et al*., 2013b). The 28 month systems have two winters of low live weight gain and therefore, can take advantage of compensatory growth, during the high nutritive value low cost summer grazing periods (Finneran *et al*., 2012), more than any of the other systems.

In general, the 28 month steer systems had the lowest live weight output per hectare but had the highest percentage of live weight gain from grass (Table 2). The three bull systems (HB16, HB19 and LB16) had the highest live weight and carcass output per hectare (Table 2) but also had the lowest net profit. Crosson *et al.* (2009) found that one of the main drivers of profitability in grass based beef production systems was carcass output per hectare. However, the bull systems in this current analysis had a higher level of concentrate intake relative to the steer and heifer systems (average kilograms of dry matter concentrate consumed per kg of carcass weight produced was 6, 2 and 1, respectively) resulting in higher feed costs and lower live weight gain from grass. Koknaroglu *et al.* (2005) and Ramsey *et al.* (2005) found that feeding higher levels of purchased feed led to higher costs and lower profits. Similarly, McRae (2003) found that it may be necessary to reduce carcass output per hectare to increase profitability per hectare where such a reduction in output is associated with an increase in the consumption of grass grown on the farm. Having a higher percentage of gain from grass also means that the cost per kilogram of gain will be lower and cost of gain was found by McDonald and Schroeder (2003) to be the second most important factor in determining the profitability of beef production systems. This, therefore, indicates that carcass output per hectare is a key driver of profitability of dairy calf-to-beef systems but it must not compromise the cost structure of the systems i.e. high carcass output per hectare must not be achieved by feeding an expensive feed source such as concentrate. In the systems studied this is achieved by maintaining a long grazing season (March to October) with high quality grass available at all times, thus ensuring that high live weight gains are maintained throughout the grazing season.

In Ireland, the number of bulls slaughtered as a percentage of total prime cattle slaughtered increased from 3 to 20% from 2000 to 2012 (Bord Bia, 2013b). This consists of animals from both the suckler and dairy cow herd and it is speculated that most of the increase in slaughtered bulls is from the suckler cow herd. The increase in bull beef production is due to bulls having a greater live weight gain, carcass gain, feed conversion ratio, conformation score and kill out proportion than steers (Seideman *et al*., 1982; Boucque *et al*., 1992; Steen, 1995; Steen and Kilpatrick, 1995; Keane, 2003; Kirkland *et al*., 2006). However, to express this greater animal production potential, bull beef cattle production systems are typically associated with higher levels of concentrate feeding. Therefore, as this study and Ashfield *et al.* (2013c) have shown, within the wide range of dairy calf-to-beef production systems investigated, bull systems have a lower net profit than steer systems. This is mainly caused by the high level of concentrate in the diet and, therefore, the increase in performance advantages (as described above) for bulls over steers is not sufficient to cover the increase in costs. This is exacerbated by the bull system's sensitivity to concentrate price which has increased by €50 per tonne between 2007 and 2012 (CSO, 2013).

Table 2: Physical outputs of dairy calf-to-beef production systems studied using the Grange Dairy Beef Systems Model

	HS24	HS28	HB16	HB19	LS24	LS28	LB16	LH21	ES20	ES22	ES28	EH19
Physical												
Number finished (animals)	127	100	241	181	127	100	241	155	167	145	100	181
Grazed grass consumed (kg DM/head)	2,698	3,898	565	1,130	2,612	3,953	661	2,152	2,276	2,655	4,017	2,016
Grass silage consumed (kg DM/head)	853	1,598	210	581	1,137	1,433	271	713	431	866	1,490	417
Concentrate consumed (kg DM/head)	841	513	1,760	1,567	724	292	1,611	488	461	329	433	210
Live weight output (kg/head)	604	685	523	596	652	720	561	545	518	573	713	450
Carcass output (kg/head)	312	343	276	315	351	395	308	287	269	297	363	230
Live weight output (kg/ha)	1,539	1,374	2,524	2,157	1,663	1,445	2,702	1,689	1,730	1,657	1,430	1,629
Carcass output (kg/ha)	794	687	1,333	1,139	895	793	1,486	890	896	858	729	832
Percentage total live weight gain from grass (%)	58	76	25	31	56	81	30	58	72	64	75	73
Labour requirement (MWU/farm)[1]	1.63	1.43	2.09	2.3	1.64	1.43	2.09	1.98	1.69	1.85	1.43	1.82

Notes: 1. MWU= Man work unit – one MWU is equal to 225 standard man days (SMD) – one SMD is equal to eight hours work by one person, SMD required per animal for calf rearing, animals outdoors and animals indoors are 1, 0.3 and 0.6, respectively, (Teagasc, 2008)

Sensitivity to price variations

Market volatility is an increasing challenge on Irish beef cattle farms with significant fluctuations in beef, fertiliser and concentrate prices in recent years (CSO, 2012). This means that the profitability of the different systems and the ranking of systems can change between years. Table 3 shows the effect of changing beef, calf, concentrate and fertiliser price on the net profit of the systems studied. Variation in beef price was found to have the largest effect on net profit especially the systems with higher beef carcass output per hectare. Fluctuations in calf price had a larger effect than concentrate price variations on all systems except the bull systems because of the high level of concentrate feed in the bull systems. Koknaroglu *et al.* (2005) found that more than 50% of the variation in profit is dictated by feed and cattle prices therefore, beef and concentrate price have an important influence on profitability. Fertiliser price changes had a small effect on all systems reflecting its lower contribution to total variable costs. The LS28 system was the most profitable and LB16 the least profitable for all variations in beef, calf, concentrate and fertiliser price. The ranking of Holstein-Friesian and late maturing systems changed within the beef price fluctuations shown in Figure 2. The fluctuation of calf, concentrate and fertiliser prices were also evaluated with calf and concentrate prices having a modest effect and fertiliser prices having no effect on the ranking of systems' profitability. The main effect of price changes was on the bull systems when beef and concentrate price is changed. Steer systems finishing cattle at grass at 28 months of age were found to be very robust to the range in prices investigated in this analysis.

Due to the large effect of changing beef price, the seasonality of beef price also has an effect on the profitability of the different systems. The seasonality of beef price is accounted for in the model with monthly variation captured based on historical data (Bord Bia, 2011). Ireland has a seasonal supply of animals to slaughter plants as a result of the numbers of beef cattle finished at grass at the end of the grazing season and the seasonality of calving with both the dairy and beef cow herds predominantly calving in spring. With the number of cattle slaughtered increasing in the autumn (August to November; AIM, 2012), animals sold in this period typically receive a lower price than animals sold in the January to July period. This is evident in the ES20 and EH19 systems which had the highest proportion of grazed grass in the diet 72% and 76%, respectively, high carcass output per hectare (896 and 832 kg ha^{-1}, respectively) and a high percentage of live weight gain from grass (72% and 73%, respectively).

However, the ES20 and EH19 systems were not the most profitable due mainly to the seasonality of beef price. However, this pattern of beef price fluctuation throughout the year does not always happen as was found in 2011 when beef price was higher for the second part of the year (Bord Bia, 2013a) due to seasonal price patterns being offset by a high demand and low supply of beef on the market. If the effect of seasonality on beef price is removed from the model it was found (Figure 3) that those systems finishing animals between August and December had an increase in net profit and those systems finishing animals between January and July had a reduction in net profit. LS28 is still the most profitable

Table 3: Financial outputs and effects of changing beef, calf, concentrate and fertiliser price on the net profit of dairy calf-to-beef production systems using the Grange Dairy Beef Systems Model (€000's per farm)

	HS24	HS28	HB16	HB19	LS24	LS28	LB16	LH21	ES20	ES22	ES28	EH19
Output												
Animal sales	163.8	145.3	280.1	229.1	194.7	176.2	325.3	184.9	177.4	174.7	159.0	169.6
Silage sales	0.0	0.0	6.1	3.0	0.0	0.0	5.7	0.0	0.0	0.0	0.0	0.0
Livestock purchases	17.5	13.9	32.6	24.6	48.5	38.5	100.6	55.4	44.1	38.3	26.9	43.9
Total output	146.3	131.4	253.6	207.5	146.1	137.8	230.4	129.5	133.3	136.3	132.2	125.8
Variable costs												
Concentrate	41.2	20.4	158.0	105.8	35.4	12.0	143.7	29.7	30.3	19.3	17.2	16.2
Grazing grassland	6.8	10.0	3.5	3.7	6.6	10.1	4.2	6.3	8.3	9.1	10.6	7.5
Silage	8.1	12.4	3.0	7.6	10.9	11.1	3.9	8.2	5.5	9.5	11.6	5.7
Other[1]	28.5	24.1	48.2	38.0	30.5	25.2	52.1	33.6	33.4	30.8	24.5	34.7
Total	84.6	66.9	212.6	155.1	83.4	58.3	203.9	77.9	77.5	68.7	63.9	64.2
Gross margin	61.8	64.6	41.0	52.4	62.8	79.4	26.6	51.6	55.8	67.7	68.3	61.6
Fixed costs[2]	29.2	30.1	27.5	31.1	29.0	30.1	30.3	35.0	32.5	35.3	30.1	31.0
Net profit	32.6	34.5	13.4	21.3	33.7	49.3	−3.8	16.6	23.3	32.4	38.2	30.6
Return on capital invested (%)	2.35	2.78	1.18	1.87	2.19	3.45	−0.33	1.18	1.74	2.45	2.75	2.23
Sensitivity (impact on net profit farm^{-1})												
Beef price (+/−10c/kg)	4.0	3.5	7.2	5.7	4.6	4.1	8.0	4.3	4.3	4.2	3.8	4.1
Calf price (+/−€10/animal)	1.5	1.2	2.9	2.2	1.5	1.2	3.2	1.9	2.0	1.8	1.2	2.2
Concentrate price (+/−€10/t)	1.4	0.6	5.6	3.7	1.2	0.4	5.1	1.0	1.0	0.6	0.5	0.5
Fertiliser price (+/−€10/t)	0.2	0.3	0.1	0.1	0.2	0.3	0.1	0.2	0.3	0.3	0.4	0.2

Notes: 1. Veterinary and medicine, slurry, straw, milk replacer, reseeding etc
2. Includes machinery, land improvements and buildings maintenance and depreciation, other fixed costs and interest paid on overdraft and long term loan

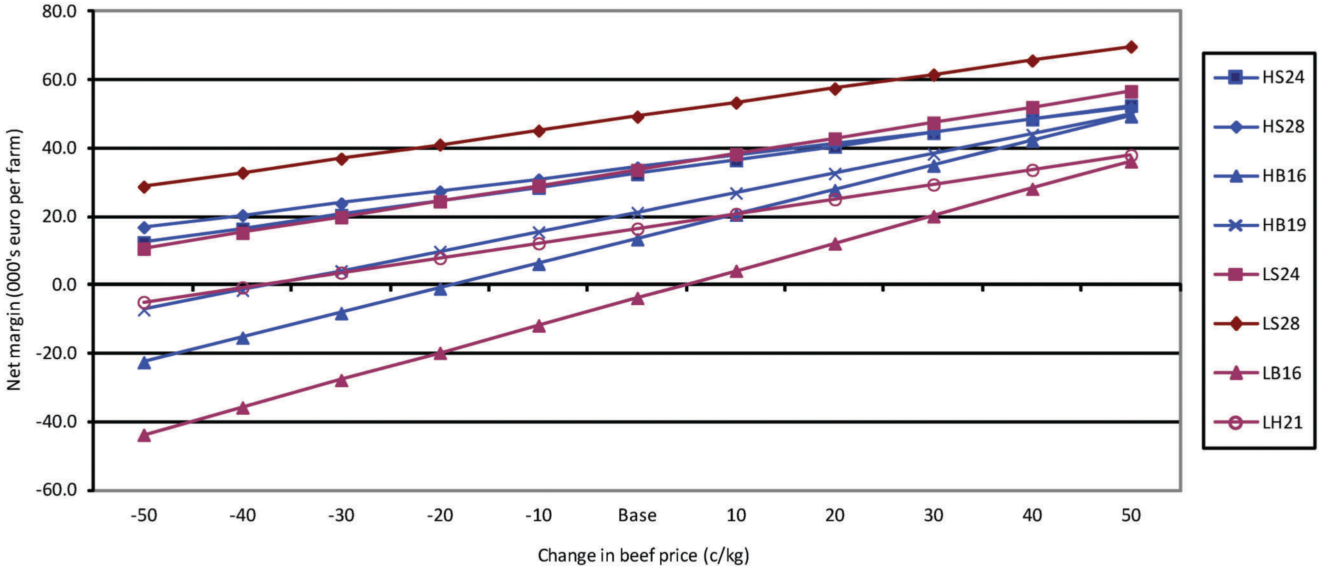

Figure 2: Effect of changing beef price on net profit of Holstein-Friesian and late maturing dairy calf-to-beef systems investigated using the Grange Dairy Beef Systems Model (all results in €000's per farm)

system and LB16 the least profitable system but the ranking of the other systems changes considerably (Table 4). This further emphasises the large effect changes in beef price can have on the profitability and ranking of the different systems.

Farmers face uncertainty about the economic consequences of their actions due to their limited ability to predict factors such as weather, prices and biological responses to different farming practices (Pannell *et al.*, 2000). Meuwissen *et al.* (2001) found that price was

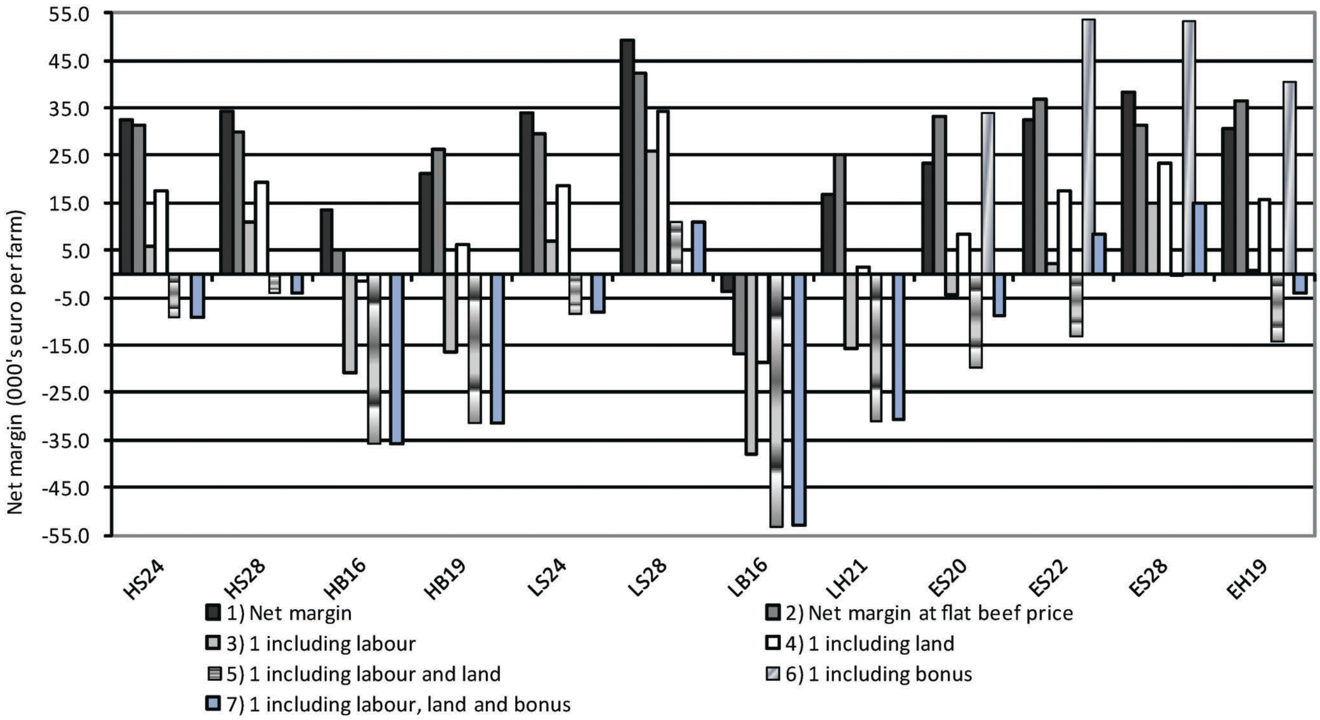

Figure 3: Profit measures for dairy calf-to-beef production systems investigated using the Grange Dairy Beef Systems Model (€000's per farm)

Notes:

1. Net profit excluding labour, land and bonus scheme paid for early maturing animals
2. Net profit with flat average beef price for the year
3. Net profit including labour
4. Net profit including land
5. Net profit including labour and land
6. Net profit including bonus scheme paid for early maturing animals
7. Net profit including labour, land and bonus scheme paid for early maturing animals

Table 4: Ranking of different dairy calf-to-beef systems to determine the effect of flat beef price, labour, land and bonus payments for early maturing animals

Rank	Ranking of systems (highest to lowest net profit per farm)											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1) Net profit	LS28	ES28	HS28	LS24	HS24	ES22	EH19	ES20	HB19	LH21	HB16	LB16
2) Net profit at flat beef price	LS28	ES22	EH19	ES20	ES28	HS24	HS28	LS24	HB19	LH21	HB16	LB16
3) 1 including labour	LS28	ES28	HS28	LS24	HS24	ES22	EH19	ES20	LH21	HB19	HB16	LB16
4) 1 including land	LS28	ES28	HS28	LS24	HS24	ES22	EH19	ES20	HB19	LH21	HB16	LB16
5) 1 including labour and land	LS28	ES28	HS28	LS24	HS24	ES22	EH19	ES20	LH21	HB19	HB16	LB16
6) 1 including bonus	ES22	ES28	LS28	EH19	HS28	ES20	LS24	HS24	HB19	LH21	HB16	LB16
7) 1 including labour, land and bonus	ES28	LS28	ES22	EH19	HS28	LS24	ES20	HS24	LH21	HB19	HB16	LB16

perceived as one of the most important sources of risk. Therefore, this study has tried to encompass some of the risk involved around changing prices and it was found that there is considerably higher risk in the bull systems than the other systems. The bull systems were found to be more sensitive to beef, calf and concentrate price changes and have greater levels of money invested in livestock and variable costs for lower net profits than other systems which lead to higher levels of financial risk. This is further emphasised by the return on capital invested for the different systems shown in Table 3. The 28 month steer systems have the least risk in terms of price sensitivity and investment in livestock and variable costs.

An important aspect of risk refers to cash flow; in this regard the 24 month systems performed best with cash flow being negative for the shortest period of time (Figure 4). Figure 4 shows the monthly closing cash flow balance for the late maturing animals with all systems assumed to be starting from a zero balance position. The very negative closing balance for LB16 in May was due to large numbers of animals purchased in February and indoor feeding costs for calves and particularly finishing bulls prior to sale in June. Thus, high concentrate feeding also adds to the financial risk of the bull systems. The simulated overdraft requirement for the system would clearly represent a significant and unacceptable liability for many farmers and may have to take the form of a bridging/short term loan.

Bonus scheme, labour and land considerations

In Ireland there is a bonus scheme at slaughter for animals with an Aberdeen Angus or Hereford sire. This scheme gives farmers up to an extra 40c kg^{-1} of carcass sold for animals that meet the requirements (sire breed, carcass weight and time of year animals are finished). These particular requirements may be difficult to meet for many farmers, however, if this bonus is included in the current analysis the EM systems net profit increased by an average of €14,000 per farm (Figure 3). Therefore, this price increase would make the majority of EM systems more profitable than all other systems with the exception of LS28. Even where a bonus was available for EM systems, LS28 remains more profitable than ES20 and EH19 (Table 4), and HS28 would have a similar net profit to ES20. However, the bonus payable for EM systems is contingent on these breeds retaining a premium brand in the market and is thus a 'niche' market with the potential for oversupply. This could have significant negative implications on the bonus price received by the farmers (Tonts and Selwood, 2003).

The economic analysis presented thus far does not take into account the opportunity cost of labour and land. However, since the labour requirements are directly related to the number of animals in each system, the bull systems had considerably higher labour requirements than other systems (Table 2) requiring over two man work unit's (MWU; one MWU is equal to 225 standard man days (SMD) one SMD is equal to eight hours work by one person, Teagasc, 2008). The 28 month steer systems had the lowest MWU requirements. All systems required more than one MWU and this extra labour could consist of family members or hired labour, however, the availability of labour is

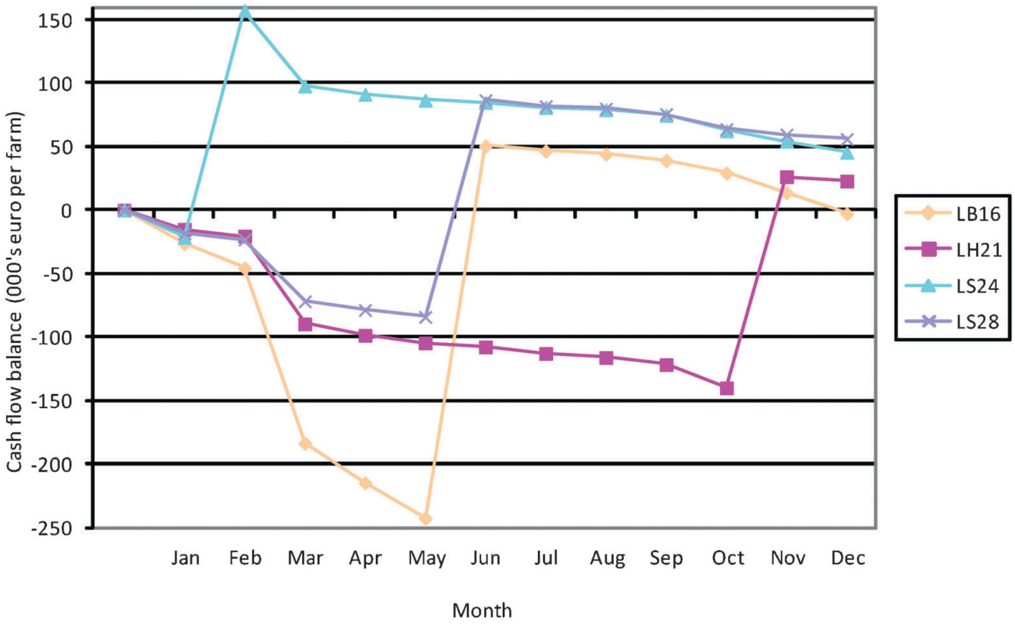

Figure 4: Cash flow of animals from late maturing dairy calf-to-beef systems investigated using the Grange Dairy Beef Systems Model (all results in €000's per farm)
Note: Opening bank balance (1st January) was assumed to be zero for all systems

decreasing on Irish farms (Frawley and Phelan, 2002). Labour requirements are seasonal with peaks in labour requirement around times such as calf rearing. There have been a number of studies into the reduction of labour requirements on Irish farms (Gleeson *et al*., 2008; O'Brien *et al*, 2006). Gleeson *et al.* (2008) found that labour requirements during calf rearing could be reduced by adopting new practices such as feeding once a day. This practice could be very important for the systems with high labour requirements such as the bull systems and could result in a reduction of total labour requirements for the systems. The net profit including the cost of labour for all systems is shown in Figure 3. For all systems labour costs averaged €29,000 (based on labour requirement taken from Table 2 and labour charge of €9.10 per hour (Irish Farmers Association (IFA), 2011)). This resulted in all bull systems, LH21 and ES20 having a negative net profit when a charge for labour was included.

Most farms in Ireland are predominantly family farm units with on average 83% of land owned (Hennessy *et al*., 2013). However, if a land charge of €300 ha^{-1} (Finneran *et al*., 2010) is applied to all land farmed including owned land, €15,000 is added to the cost of all systems (Figure 3). When labour and land charges are included (Figure 3) the only system to have a positive net profit is LS28. This shows the importance of considering labour and land charges when evaluating the profitability of the different systems and farmers need to ensure sufficient returns to cover these. When labour, land and bonus payments are all included the only systems to have a positive net profit are ES28, LS28 and ES22 (Figure 3).

4) Looking to the future

In 2011 there were approximately 1.1 million dairy cows in Ireland (AIM, 2012). The majority (63%) of these dairy cows were mated to a FR sire, 9% to a Limousin, Charolais or Belgian Blue sire and 22% to a Aberdeen Angus or Hereford sire with the remaining dairy cows mated to other breeds. The number of male animals from the dairy herd available for beef production in 2011 was 347,000, 121,000 and 22,000 for FR, EM and LM animals, respectively. Heifer numbers are more difficult to calculate due to the retention of a proportion of the EM and LM heifers as replacements for the suckler beef cow herd. Thus, it is clear that despite the LS28 system being the most profitable, the availability of LM calves from the dairy herd will limit the potential to exploit this finding. However, irrespective of the breed of animal the current study has shown that the most profitable system across all breeds is finishing animals at 28 months of age and this finding is supported by Ashfield *et al.* (2013a,b). The high ratio of FR animals to LM and EM animals could change in the future due to an increase in the number of dairy cows in Ireland after the abolition of milk quota in 2015 (European Commission, 2009) and the uptake of sexed semen due to the advantages outlined by Hutchinson *et al.* (2013). This could result in a larger number of beef breed (LM and EM) animals and lower number of FR animals being available for beef production. Furthermore, this could also lead to an increase in the number of heifer calves because natural service (i.e. cows served by a breeding bull) is likely to be the source of LM and EM sires resulting in a more even split in gender ratio. The selection of beef sires for use on dairy cows is driven by the requirements of the dairy farmer and thus shorter gestation length and lower incidence of calving difficulty will be most important. This would favour the use of EM rather than LM sires (Keane, 2002; ICBF, 2006).

In Ireland the majority of dairy cows calve in the spring (February-April; AIM, 2012). The majority of FR animals are born earlier followed by LM and EM animals due to Holstein-Friesian sires being used at the start of the breeding season to breed replacement heifers for the dairy herd. There is a range in calf birth dates with the majority of animals born from January to April which could affect the net profit of the different systems. In the current study the calf birth date is set as February for FR calves and March for LM and EM calves. Unpublished work based on ongoing breed and system comparison experiments at the Animal and Grassland Research and Innovation Centre, Teagasc, Johnston Castle looking at EM animals born in February or April would suggest that the animals born in April are more profitable (Prendiville *et al.*, 2013), however, more work is required to determine the underlying profit drivers leading to these differences.

The 16 month bull beef systems are unlikely to be managed as individual systems due to the challenges with regard to grassland management as only calves consume grazed grass for a short grazing season (May-October). The bull systems all required excess grass from the grazing area to be harvested as round bale grass silage and sold off farm. This system is more likely to be run in parallel with another production system to facilitate better synchrony of total farm grazed grass demand and grass growth. McRae (2003) states that it may be necessary to run different ages and classes of livestock on the same farm, to ensure higher profits per hectare through the better utilisation of grass. In Ireland dairy calf-to-beef production systems are seldom run as stand-alone systems and usually in conjunction with another enterprise (suckler beef cows, dairy cows, sheep). Results from Ashfield *et al.* (2013c) found that there was no advantage to the combining of different dairy calf-to-beef systems; however, this was in the context of rigid production systems with set feeding systems, fixed dates for turnout to grazing and housing for indoor feeding. It is possible that a more flexible approach to combining production systems taking into account the specific requirements of different systems and the variability of grass growth might permit higher profit tailored combination systems to be developed. A further area of possible future research could be looking at combining suckler beef cow or dairy cow systems through combining the GDBSM with the Grange Beef Systems Model (Crosson, 2008) or the Moorepark Dairy Systems Model (Shalloo *et al.*, 2004), respectively, to determine if combining these systems could lead to an increased net profit for the farm. In the current study it was not possible to analyse LM 19 month bull systems or 16 and 19 month EM bull systems because there is no research data available for these systems and therefore, this is an area where future research could be conducted. Although in this current study we have calculated a labour requirement figure for the systems based on data from Teagasc (2008) this uses a very basic method based on the age of the animal. Therefore, further research should be conducted in the area of labour requirements on dairy calf-to-beef farms to more accurately account for the labour required and associated costs for the different systems. All the systems analysed in the current study are assumed to have a very high level of management by the farmer. Clearly the level of management and animal husbandry has a critical impact on overall farm system productivity and consequently profitability. Therefore, another area of future research could be modelling the effects of poorer management such as reduced live weight gain or grass utilisation on net profit. The results from the current study would imply that future research prioritisation should be focused on maximising the proportion of grazed grass in the diet and the percentage of live weight gain from grazed grass while maintaining a high carcass output per hectare (through the production and utilisation of more grazed grass) as these are three of the main drivers of profitability in dairy calf-to-beef systems.

5) Conclusion

The GDBSM was used to compare the profitability of a number of dairy calf-to-beef production systems differing in breed, gender and finishing age. The most profitable system was found to be finishing late maturing animals at 28 months of age during their third summer grazing period (LS28). Variations in beef and concentrate price were found to have a significant effect on the ranking of systems. The main drivers of profitability were found to be maximising the proportion of grazed grass in the diet and percentage of live weight gain from grass while also maintaining a high carcass output per hectare.

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