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A comparison of production systems and identification of profit drivers for Irish suckler beef farms

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ABSTRACT

The objective of this study was to determine the effect of production system (Finishing, calf-to-slaughter; Live, calf-to-live sale; Mixed, a combination of Finishing and Live) on the profitability of suckler beef farms in Ireland and furthermore, to identify the key drivers of profitability. The financial records of 38 farms participating in a knowledge transfer programme, over a 7 year period, were used. Finishing (58.4 hectares (ha) and 119.2 livestock units (LU)) and Mixed (60.5 ha and 114.7 LU) farms had greater ($P<0.05$) size and number of livestock units than Live farms (45.0 ha and 84.4 LU). Beef live weight output per ha and gross output (GO) value per LU and per ha was greater ($P<0.05$) on Finishing farms than Mixed farms. Finishing farms had the highest ($P<0.01$) concentrate costs per ha, whereas contractor costs per LU were highest ($P<0.05$) on Mixed farms. No difference ($P>0.05$) in net margin (NM) per LU or per ha was found between production systems. Although physical output, in relation to stocking rate and beef live weight, was found to be an important driver of profitability, total costs per kg output was similarly strongly correlated with gross and net margin. Therefore, reducing the level of expenditure incurred per kg output produced is imperative to improving suckler beef farm profitability.

KEYWORDS: financial performance; net margin; profit drivers; production efficiency; suckler beef farms

1. Introduction

Ireland is the fifth largest net exporter of beef in the world, exporting 90% of the total 520,000 tonnes of carcass weight produced annually, valued at just under €2.1 billion[4]. A further 210,000 cattle, worth €162 million, are exported live (Bord Bia, 2013). This combined value of output from carcasses and live animals is predominantly generated from the progeny of the suckler beef cow herd, which comprises approximately 1.1 million of the total 2.3 million cows in Ireland (CSO, 2015a), with the remainder originating from the dairy sector. Beef production activities occur on almost 80% of Irish farms (Renwick, 2013) and accordingly, the beef sector is a primary contributor to the Irish agri-food industry accounting for 34% of total gross output (GO) value in 2014 (DAFM, 2015).

However, despite its significance to the national economy, farm family incomes are low; the National Farm Survey (Hennessy and Moran, 2016), which is part of the Farm Accountancy Data Network in the EU (European Commission, 2016), provides information on output, costs and income of Irish farms. Average suckler beef farm income (including the EU direct payments and agri-environmental scheme subsidies) was €12,904 in 2015 with income on beef finishing farms 26% higher at €16,215 (Hennessy and Moran, 2016). This compares with an average annual industrial wage in Ireland in 2013 of €35,768 (CSO, 2015b). On these farms, the EU direct payments and agri-environmental subsidies represented 102% and 95% of farm family income, respectively. The level of off-farm employment by farmer and/or spouse on suckler beef and beef finishing farms is high at 60% and 48%, respectively (Hennessy and Moran, 2015). Therefore, beef farms in Ireland are heavily reliant on EU payments, and alternative sources of income outside of the farm to support the farm family (Hennessy and Rehman, 2008; Hennessy and Moran, 2016). Ireland is not unique in this respect, with beef farming globally having low levels of profitability as a result of poor productivity, inefficient farm management and biological factors (Rakipova *et al.*, 2003; Newman and Matthews, 2007; Deblitz, 2010; Barnes, 2012). The economic sustainability of beef farms is further hindered by the high sensitivity of these systems to input and output price volatility (Mosnier *et al.*, 2009).

Improving the level of farm efficiency, such as increasing the number of calves produced per cow annually

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[4] At the time of writing (September 2016), €1 was approximately equivalent to £0.86 and $US1.12.
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(Crosson and McGee, 2011) or increasing live weight gain of growing and finishing cattle (Crosson *et al.*, 2009), can improve the resilience of farm system economics by reducing production costs per kilogramme of output. Of particular relevance to Irish beef cattle production systems is the capacity to grow high yields of grass over a long growing season. Correspondingly, grass when grazed in situ is one of the cheapest sources of ruminant animal feed available being 56%, 51% and 30% of the cost of grass silage, whole crop maize silage and purchased rolled barley, respectively (Finneran *et al.*, 2012). Thus, Crosson and McGee (2015) found that beef farms with a longer grazing season were the most profitable. For this reason, ruminant livestock systems in Ireland are predominantly pasture-based with the majority of suckler beef cows calving in spring in order to coincide with the onset of seasonal grass growth.

The production system operated on beef farms influences profitability. For example, McGee *et al.* (2014) showed that suckler calf-to-beef systems were more profitable than selling earlier in the animals' lifetime. Similarly, Crosson and McGee (2015) found systems finishing their own progeny were more profitable than systems selling progeny for further feeding directly after weaning. Furthermore, this study found differences within calf-to-beef finishing systems concluding that finishing male progeny as bulls, compared to steers, resulted in a higher net margin.

Recent research examining Irish beef farm profitability (Finneran and Crosson, 2013) benchmarked farms in terms of financial performance per livestock unit (LU) and concluded that greater income was linked to reduced levels of both concentrate feed usage and overhead costs per LU. This research also found that demographics such as farmer age and level of off-farm employment did not differ between the top and bottom third of farms. However, this study included both suckler beef and non-suckler beef farms and therefore, did not permit a comparison of trading options and profit drivers within suckler beef systems. Furthermore, a detailed interrogation of factors affecting the profitability of suckler beef systems was not possible. This is as a result of using FADN data (European Commission, 2016), which is a representative dataset of national performance and therefore includes farms which have non-farm sources of income and therefore, maximising profitability is often not the single or primary driver of all production decisions. Thus, the present study aims to overcome this limitation by using a group of farms that are participating in a knowledge transfer programme and are therefore, focused on profit maximisation through improving technical efficiency and animal performance.

Therefore, the objectives of this study were, for suckler beef farms in Ireland which are focussed on maximising profitability, 1) to determine if differences in profitability exist across different production systems, and, 2) identify, and quantify, the main profit drivers on these farms.

2. Materials and methods

A minimum of 3 years financial records were collected from each of 38 suckler beef farms over a 7-year period (2008–2014). All farms participated in a knowledge transfer programme, the Teagasc/Irish Farmers Journal *Business, Environment and Technology through Training, Extension and Research* (BETTER) farm beef programme (Teagasc, 2015). Farms participating in the programme received intensive advisory support in three key areas of farm operation; 1) grassland and animal nutrition management, 2) animal husbandry with specific reference to cow reproductive performance and progeny live weight performance, and, 3) business management with a particular focus on record keeping and farm planning. However, this study is not an analysis of the effectiveness of this knowledge transfer programme since records, where available, for years prior to or following farms' participation were included in the analysis.

Farms were categorised into one of three groups of production systems based on the type of animal sales within a year; Finishing (suckler calf-to-beef, selling progeny directly to commercial abattoirs for slaughter), Live (suckler calf-to-live sale, selling progeny post-weaning to the live market) or Mixed (a combination of both Live and Finishing). Assignment of farms to a specific category was based on the criteria that within a year, a farm sells at least 75% of its animals for slaughter or live sale to be categorised as Finishing or Live, respectively, otherwise the farm was categorised as Mixed. This resulted in the total number of observations over the 7-year period (2008–2014) for Finishing, Live and Mixed farms being 49, 85 and 93, respectively (Table 1).

Data were recorded by each farmer's local extension advisor using the Teagasc eProfit Monitor software (Teagasc, 2016a). The Teagasc eProfit Monitor is an online farm financial analysis tool used to record all farm inputs and outputs during a single production year. Physical farm measures included farm size, livestock numbers, production type, stocking rate and beef output. Financial measures included value of sales and purchases of livestock, variable and fixed costs. Variable costs included: concentrate feedstuff, fertiliser, contractor, veterinary and other (purchased forage, transport, straw, levies and miscellaneous items). Fixed costs included: machinery repairs, lease and running expenses, utility expenses, casual labour and bank loans and interest charges. Building and machinery depreciation were included under fixed costs and were calculated using 5% and 10% straight line depreciation, respectively. Practically all the farms (37 out of 39) in the dataset comprised of almost entirely owned, rather than leased, land. Therefore, in order to facilitate comparative analysis, it was assumed that the two predominantly leased farms were also owned and thus, leased land charges were excluded. Farmers' own labour has been omitted from the study due to an absence of records in relation to hours worked, or number

Table 1: Number of farms within each system by year

Year	System			Total
	Finishing	Live	Mixed	
2008	3	9	14	26
2009	1	13	13	27
2010	5	15	14	34
2011	7	13	18	38
2012	9	13	15	37
2013	11	11	14	36
2014	13	11	5	29
Total	49	85	93	227

of family labour units on the farm. Therefore, net margin generated on these farms is, in effect, a return for owned land and own labour. This is an approach used previously (Hennessy and Moran, 2016; Teagasc, 2016b).

All prices were corrected for yearly inflation according to the CSO price index (CSO, 2015c) using 2014 as the base year to more accurately reflect technical farm performance (Table 2). Key commodities such as cattle and beef price, fertiliser price, veterinary expenses and concentrate feed price were corrected for inflation using category specific inflation indices. All other input expenses were corrected for inflation using the general agricultural input category (Table 2). For benchmarking purposes, data was calculated per hectare (ha) and per LU (1 suckler cow = 0.9 LU) for each farm.

Statistical analysis

Model assumptions (constant variance and normal distribution) were checked using residual diagnostics. Where appropriate, log transformation was used to correct for skew and non-constant variance. Variables log transformed included concentrates per ha, per LU and as a percentage of GO, fertiliser as a percentage of GO, veterinary costs per ha and other variable costs per ha and as a percentage of GO. Means from the log scale analysis were back-transformed as medians on the data scale. As the log scale standard error could not be straightforwardly back-transformed, 95% confidence limits were produced on the log scale and the end-points were back-transformed to produce asymmetric confidence intervals on the data scale. There were few outliers and they were checked both before and after transformation in the case of variables that were log-transformed. If an outlier was determined to be influential then the analysis was repeated with and without the outlier. There was only one instance of a change in the overall conclusion where, for veterinary costs as a percentage of gross output, the result went from a tendency to significant and there was no change in which systems means were significantly different to each other. Log transformations and outlier checking resulted in acceptable residual plots in all cases. A repeated measures model was fitted to model production system with adjustment for year to allow for changes in conditions from one year to the next using the GLIMMIX procedure in SAS 9.4 (SAS, 2014). Means for production system were compared pairwise using Tukey adjustment. Statistical significance was determined as $P<0.05$ and a reported tendency as $P<0.10$. Using the CORR procedure in SAS 9.4, Pearson residuals were calculated within production system and cost variables were transformed as appropriate. A correlation of less than 0.30 was classified as 'weak', 0.30 to 0.69 as 'moderate' and 0.70 and greater as 'strong'.

3. Results

Physical and financial output

Table 3 outlines the system differences in physical farm factors, live weight output and value of output produced. There was no difference ($P>0.05$) between systems in suckler cow numbers and stocking rate, while farm size and number of LU were greater ($P<0.05$) for Finishing and Mixed farms than Live farms. Live weight output per LU showed a tendency ($P=0.064$) to be higher on Finishing farms than Live and Mixed farms. Live weight output per ha and value of output produced per LU and per ha was higher ($P<0.05$) for Finishing farms than Live and Mixed farms.

Production costs and margins

Table 4 shows differences in costs and margins across system per LU and per ha. Contractor costs per LU were

Table 2: Market inflation of cattle/beef price, fertiliser price, veterinary price, concentrate feed price and agricultural commodity input price from 2008-2014 in relation to the base year (2014=1.0) (CSO, 2015c)

	2008	2009	2010	2011	2012	2013	2014
Cattle/beef	0.87	0.78	0.79	0.96	1.08	1.1	1
Fertiliser	1.14	0.92	0.82	1.01	1.04	1.04	1
Veterinary	0.95	0.97	0.98	0.97	0.98	0.98	1
Concentrate	0.95	0.83	0.82	0.95	1.02	1.11	1
Input[1]	0.96	0.88	0.87	0.97	1.02	1.05	1

[1] Agricultural commodity input price.

Table 3: System comparisons of suckler cow numbers, farm size, number of livestock units (LU), stocking rate, and live weight output and gross output value on a per LU and per ha basis

		System (S)				
		Finishing	Live	Mixed	s.e.	P-value
Suckler cows (head)		62.1	56.3	66.2	5.40	NS
Farm size (ha)		58.4^{a}	45.0^{b}	60.5^{a}	4.41	*
Livestock units (LU)		119.2^{a}	84.4^{b}	114.7^{a}	9.35	*
Stocking rate (LU/ha)		2.03	1.91	1.90	0.06	NS
Live weight output	(kg/LU)	349	316	328	9.1	0.064
	(kg/ha)	713^{a}	605^{b}	627^{b}	29.4	*
Gross output value	(€/LU)	899^{a}	801^{b}	803^{b}	24.3	*
	(€/ha)	1561^{a}	1292^{b}	1294^{b}	66.5	*

$^{a-b}$ Rows with common superscripts do not differ ($P>0.05$).

Table 4: Comparison of cost categories and gross and net margin per hectare (€/ha) and per livestock unit (€/LU) for Finishing, Live and Mixed farms

	Costs	Finishing	Live	Mixed	s.e.	P-value
€/LU	Concentrate^	129[2]	122[3]	114[4]	–[1]	NS
	Fertiliser	84	91	83	3.9	NS
	Contractor	60[ab]	51[b]	62[a]	3.9	*
	Veterinary	50	55	50	2.8	NS
	Other variable	91	80	82	5.2	NS
	Total variable	440	425	431	17.3	NS
	Total fixed	215	206	220	13.4	NS
	Total	646	627	652	17.5	NS
	Gross Margin	462	383	372	33.2	NS
	Net Margin	248	176	160	34.6	NS
€/ha	Concentrate^	309[a,5]	182[b,6]	193[b,7]	–[1]	**
	Fertiliser	169	174	153	10.7	NS
	Contractor	115	112	101	13.2	NS
	Veterinary^	80[8]	104[9]	84[10]	–[1]	NS
	Other variable^	152[11]	142[12]	130[13]	–[1]	NS
	Total variable	924	789	748	57.1	NS
	Total fixed	385	375	390	44.2	NS
	Total	1311	1161	1137	68.2	NS
	Gross Margin	637	501	543	51.6	NS
	Net Margin	252	127	155	67.4	NS

[a-b] Rows with common superscripts do not differ (P > 0.05).^ Variables log-transformed.
[1] No SE but lower and upper 95% confidence limits as follows: [2]105, 157; [3]104, 142; [4]99, 132; [5]242, 393; [6]149, 223; [7]161, 232; [8]64, 101; [9]86, 126; [10]70, 99; [11]124, 186; [12]120, 168; [13]112, 151.

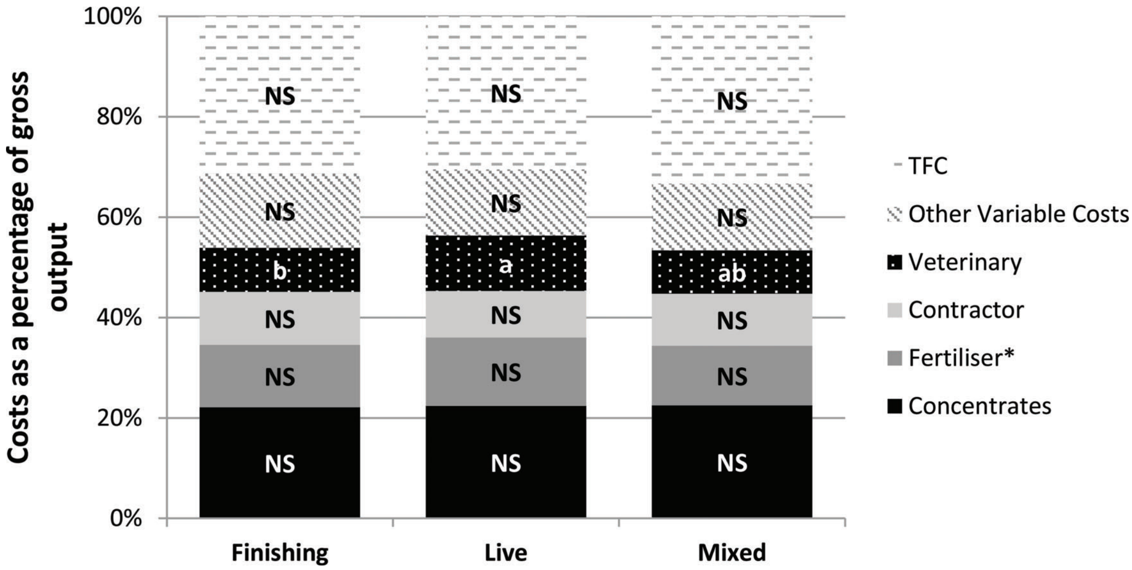

Figure 1: System analysis of components of total costs expressed as a percentage of gross output value.
[a-b] Rows with common superscripts do not differ (P > 0.05).
* Fertiliser costs – tendency for Live farms to be greater than Finishing and Mixed farms (P=0.051).

higher ($P < 0.05$) on Mixed farms than Live farms. Finishing farms had higher ($P < 0.01$) concentrate costs per ha than Live and Mixed farms. No significant differences ($P > 0.05$) were found between systems for all other variables. No differences ($P > 0.05$) were observed between systems for gross margin (GM) or net margin (NM) expressed per LU or per ha basis.

Figure 1 shows differences in costs as a percentage of GO across systems. Veterinary costs as a percentage of GO were found to be greater on Live farms ($P < 0.05$) than Finishing and Mixed farms. No other significant differences between costs as a percentage of GO were found ($P > 0.05$) across systems, however in relation to fertiliser costs as a percentage of GO ($P=0.051$) there was a tendency for Live farms to be greater than Finishing and Mixed farms.

Correlation analysis

Relationship between output measures and gross and net margin

Table 5 highlights the relationships among farm size, stocking rate, beef live weight output and GO with GM and NM expressed on a per LU and per ha basis within Finishing, Live and Mixed farms. For all systems GO per LU and ha was significantly correlated with GM and NM per LU and ha. On Finishing farms, GM and NM per ha were also significantly, positively correlated with stocking rate and beef live weight output per ha.

Table 5: Pearson correlation analysis of farm size, stocking rate, beef live weight output and gross output with gross margin and net margin per LU and per ha within Finishing, Live and Mixed systems

			Farm Size (ha)	Stocking rate (LU/ha)	Beef live weight output (kg)		Gross output (€)	
					LU	ha	LU	ha
Finishing	Gross Margin	€/LU	-0.07 (NS)	0.01 (NS)	0.10 (NS)	0.11 (NS)	0.90***	0.46***
		€/ha	-0.10 (NS)	0.35*	0.24 (NS)	0.41**	0.39**	0.52***
	Net Margin	€/LU	-0.05 (NS)	0.02 (NS)	0.09 (NS)	0.12 (NS)	0.81***	0.44**
		€/ha	0.23 (NS)	0.46***	0.17 (NS)	0.41**	0.42**	0.61***
Live	Gross Margin	€/LU	-0.03 (NS)	-0.16 (NS)	0.47***	0.20 (NS)	0.88***	0.40***
		€/ha	0.03 (NS)	0.15 (NS)	0.55***	0.48***	0.48***	0.66***
	Net Margin	€/LU	-0.06 (NS)	-0.15 (NS)	0.53***	0.26*	0.80***	0.49***
		€/ha	0.25*	0.01 (NS)	0.43***	0.30**	0.42***	0.53***
Mixed	Gross Margin	€/LU	0.06 (NS)	0.18 (NS)	0.25*	0.28**	0.76***	0.44***
		€/ha	0.34***	0.39***	0.23*	0.38***	0.31**	0.54***
	Net Margin	€/LU	0.08 (NS)	0.12 (NS)	0.16 (NS)	0.17 (NS)	0.68***	0.40***
		€/ha	0.29**	0.38***	0.16 (NS)	0.36***	0.27**	0.53***

On Live farms, NM per ha showed a significant, positive correlation with farm size. All measures of GM and NM were positively correlated with all measures of beef live weight output with the exception of GM per LU which was not correlated with beef live weight output per ha.

On Mixed farms, GM per LU and per ha was significantly, positively correlated with all measure of beef live weight output. GM per ha was also positively correlated with farm size and stocking rate. NM per LU was positively correlated with all variables except beef live weight per LU.

Relationship among cost categories and farm output and net margin

On Finishing farms, farm size was significantly, positively correlated with concentrate costs per LU and negatively correlated with contractor costs, veterinary costs, other variable costs and fixed costs per ha (Table 6). Stocking rate was positively correlated with concentrate, fertiliser and veterinary costs per ha. Beef live weight output per LU was positively correlated with contractor and veterinary costs per ha while beef live weight output per ha was correlated with concentrate, contractor, veterinary and other variable costs per ha. GO per LU was correlated with fertiliser costs per ha and contractor costs per LU. GO per ha showed a significant, positive correlation with all cost categories per ha except fixed costs. NM per LU was negatively correlated with all cost categories per LU except other variable costs while NM per ha was negatively correlated with fixed costs per ha.

Within Live farms, farm size was significantly, negatively correlated with all cost categories on a per ha basis except other variable costs (Table 7). Stocking rate was negatively correlated with concentrate costs per LU and positively correlated with concentrate, fertiliser, veterinary and fixed costs per ha. Beef live weight output and GO per ha was positively correlated with concentrate, fertiliser and veterinary costs per ha. GO per LU was positively correlated with fertiliser and fixed costs per LU and negatively correlated with concentrate and fertiliser costs per ha. NM per LU showed negative correlations with fertiliser costs per ha and veterinary costs per LU, while NM per ha was negatively correlated with concentrate, other variable and fixed costs per ha.

On Mixed farms, farm size was negatively correlated with fertiliser costs per ha (Table 8). Stocking rate was positively correlated with all cost categories per ha except fixed costs. Beef live weight output per LU was correlated with concentrate costs per ha and contractor costs per LU, while beef live weight output and GO per ha was positively correlated with all cost categories per ha except fixed costs. GO per LU was correlated with concentrate, fertiliser and other variable costs per LU and on a per ha basis, with other variable costs. NM per LU showed negative correlations with contractor and fixed costs per LU and other variable costs per ha, while NM per ha was negatively correlated with fixed costs per ha.

Table 9 shows the correlations between costs as a percentage of GO and total costs (TC) of production per kg output with GM and NM per LU and per ha across Finishing, Live and Mixed farms. All relationships were negatively correlated. On Finishing farms, GM per LU was significantly correlated with all cost categories except total costs per kg output. GM per ha was correlated with fertiliser, contractor, veterinary and other variable costs as a percentage of GO. NM per LU was correlated with all cost categories, while NM per ha was correlated with fertiliser, contractor and veterinary costs as a percentage of GO.

In the context of Live farms, GM per LU was correlated with all cost categories except fixed costs. GM and NM per ha was correlated with fertiliser, other variable and fixed costs as a percentage of GO as well as TC per kg output. NM per LU was correlated with all cost categories.

On Mixed farms, GM and NM per LU were correlated with all cost categories. GM per ha was correlated with all cost categories except concentrates as a percentage of gross output while NM per ha was correlated with all cost categories except concentrate and contractor costs as a percentage of gross output.

4. Discussion

Given the low levels of profitability on Irish suckler beef farms, the aim of this study was to use the financial and technical records pertaining to a group of 38 suckler beef farms who were known to be commercially motivated in order to determine if production system has an effect on farm profitability. Furthermore, using these detailed financial records, a second aim was to identify key drivers of profitability within the various suckler beef production systems.

Table 6: Pearson correlation analysis of farm size, stocking rate, beef live weight output, gross output and net margin with costs (€) on a per LU and per ha basis on Finishing farms

		Cost categories											
		Concentrate		Fertiliser		Contractor		Veterinary		Other variable		Fixed	
		LU	ha	LU	ha	LU	ha	LU	ha	LU	ha	LU	ha
Farm size (ha)		0.33*	-0.05 (NS)	0.05 (NS)	-0.13 (NS)	0.05 (NS)	-0.58***	0.24 (NS)	-0.30*	0.12 (NS)	-0.35*	-0.04 (NS)	-0.42**
Stocking rate (LU/ha)		0.16 (NS)	0.40**	-0.13 (NS)	0.48***	-0.14 (NS)	0.24 (NS)	-0.13 (NS)	0.44**	-0.09 (NS)	0.25 (NS)	-0.06 (NS)	-0.11 (NS)
Beef live weight output	kg/LU	-0.10 (NS)	0.18 (NS)	-0.04 (NS)	-0.05 (NS)	-0.07 (NS)	0.31*	-0.05 (NS)	0.35*	-0.09 (NS)	0.21 (NS)	0.01 (NS)	0.12 (NS)
	kg/ha	-0.01 (NS)	0.38**	-0.13 (NS)	0.26 (NS)	-0.12 (NS)	0.39**	-0.10 (NS)	0.51***	-0.11 (NS)	0.31*	-0.05 (NS)	0.02 (NS)
Gross output	€/LU	-0.16 (NS)	0.13 (NS)	-0.08 (NS)	0.34*	-0.34***	-0.13 (NS)	-0.01 (NS)	0.26 (NS)	-0.06 (NS)	0.23 (NS)	0.05 (NS)	-0.01 (NS)
	€/ha	-0.10 (NS)	0.56***	-0.28 (NS)	0.51***	-0.17 (NS)	0.41**	-0.14 (NS)	0.64***	-0.18 (NS)	0.32*	-0.05 (NS)	-0.08 (NS)
Net Margin	€/LU	-0.49***	0.19 (NS)	-0.50***	0.26 (NS)	-0.52***	0.02 (NS)	-0.33*	0.17 (NS)	-0.21 (NS)	0.29 (NS)	-0.39**	0.03 (NS)
	€/ha	0.13 (NS)	0.08 (NS)	-0.22 (NS)	0.22 (NS)	-0.26 (NS)	-0.21 (NS)	-0.05 (NS)	0.16 (NS)	-0.06 (NS)	-0.10 (NS)	-0.02 (NS)	-0.33*

Table 7: Pearson correlation analysis of farm size, stocking rate, beef live weight output, gross output and net margin with costs (€) on a per LU and per ha basis on Live farms

		Cost categories											
		Concentrate		Fertiliser		Contractor		Veterinary		Other variable		Fixed	
		LU	ha	LU	ha	LU	ha	LU	ha	LU	ha	LU	ha
Farm size (ha)		0.03 (NS)	-0.27*	0.21 (NS)	-0.22*	-0.05 (NS)	-0.24*	0.10 (NS)	-0.23*	0.12 (NS)	-0.11 (NS)	0.06 (NS)	-0.41***
Stocking rate (LU/ha)		-0.26*	0.48***	-0.21 (NS)	0.71***	-0.00 (NS)	0.18 (NS)	0.15 (NS)	0.45***	0.01 (NS)	0.18 (NS)	-0.04 (NS)	0.22*
Beef live weight output	kg/LU	0.01 (NS)	0.00 (NS)	0.11 (NS)	-0.01 (NS)	-0.08 (NS)	-0.12 (NS)	-0.04 (NS)	0.01 (NS)	-0.07 (NS)	0.06 (NS)	-0.09 (NS)	0.06 (NS)
	kg/ha	-0.15 (NS)	0.32**	-0.06 (NS)	0.46***	-0.05 (NS)	0.02 (NS)	0.07 (NS)	0.31**	-0.04 (NS)	0.17 (NS)	-0.12 (NS)	0.20 (NS)
Gross output	€/LU	0.18 (NS)	-0.22*	0.28**	-0.33**	-0.13 (NS)	-0.17 (NS)	0.01 (NS)	-0.11 (NS)	0.10 (NS)	0.19 (NS)	0.26*	-0.02 (NS)
	€/ha	-0.15 (NS)	0.34**	-0.06 (NS)	0.49***	-0.13 (NS)	0.09 (NS)	0.10 (NS)	0.47***	0.00 (NS)	0.13 (NS)	-0.09 (NS)	0.07 (NS)
Net Margin	€/LU	-0.16 (NS)	-0.04 (NS)	-0.14 (NS)	-0.23*	-0.21 (NS)	-0.07 (NS)	-0.27*	-0.05 (NS)	-0.09 (NS)	0.10 (NS)	-0.13 (NS)	0.03 (NS)
	€/ha	0.05 (NS)	-0.30**	0.07 (NS)	-0.20 (NS)	-0.02 (NS)	-0.20 (NS)	0.17 (NS)	-0.05 (NS)	-0.07 (NS)	-0.28*	-0.07 (NS)	-0.52***

Table 8: Pearson correlation analysis of farm size, stocking rate, beef live weight output, gross output and net margin with costs (€) on a per LU and per ha basis on Mixed farms

		Cost categories											
		Concentrate		Fertiliser		Contractor		Veterinary		Other variable		Fixed	
		LU	ha	LU	ha	LU	ha	LU	ha	LU	ha	LU	ha
Farm size (ha)		0.18 (NS)	-0.04 (NS)	0.14 (NS)	-0.22*	-0.02 (NS)	-0.10 (NS)	0.07 (NS)	-0.17 (NS)	0.02 (NS)	-0.01 (NS)	-0.03 (NS)	-0.01 (NS)
Stocking rate (LU/ha)		-0.12 (NS)	0.55***	-0.17 (NS)	0.47***	-0.02 (NS)	0.31**	-0.14 (NS)	0.52***	-0.07 (NS)	0.36***	0.07 (NS)	-0.07 (NS)
Beef live weight output	kg/LU	-0.04 (NS)	0.38***	0.14 (NS)	-0.05 (NS)	-0.25*	0.12 (NS)	0.11 (NS)	0.06 (NS)	-0.04 (NS)	0.09 (NS)	0.12 (NS)	0.04 (NS)
	kg/ha	-0.12 (NS)	0.63***	-0.03 (NS)	0.33**	-0.15 (NS)	0.28**	-0.02 (NS)	0.40***	-0.06 (NS)	0.31**	0.15 (NS)	-0.05 (NS)
Gross output	€/LU	0.39***	0.06 (NS)	0.39***	-0.09 (NS)	-0.10 (NS)	0.06 (NS)	0.08 (NS)	0.01 (NS)	0.22*	0.27**	0.03 (NS)	-0.01 (NS)
	€/ha	-0.09 (NS)	0.63***	-0.05 (NS)	0.46***	-0.15 (NS)	0.31**	-0.04 (NS)	0.52***	-0.03 (NS)	0.32**	0.01 (NS)	-0.10 (NS)
Net Margin	€/LU	0.19 (NS)	0.04 (NS)	-0.06 (NS)	-0.08 (NS)	-0.34**	0.07 (NS)	-0.12 (NS)	0.08 (NS)	-0.08 (NS)	0.22*	-0.43***	0.10 (NS)
	€/ha	0.15 (NS)	0.09 (NS)	0.01 (NS)	-0.06 (NS)	0.14 (NS)	-0.02 (NS)	0.05 (NS)	-0.07 (NS)	-0.05 (NS)	-0.12 (NS)	-0.15 (NS)	-0.57***

Table 9: Correlation analysis of costs as a percentage of gross output and cost of production per kg output with gross margin and net margin on Finishing, Live and Mixed farms

			Concentrate costs	Fertiliser costs	Contractor costs	Veterinary costs	Other variable costs	Fixed costs	Total costs per kg output
Finishing	Gross Margin	€/LU	-0.75***	-0.68***	-0.68***	-0.72***	-0.61***	-0.31*	-0.23 (NS)
		€/ha	-0.07 (NS)	-0.29*	-0.41**	-0.29*	-0.45**	-0.09 (NS)	-0.12 (NS)
	Net Margin	€/LU	-0.70***	-0.77***	-0.68***	-0.67***	-0.52***	-0.62***	-0.38**
		€/ha	-0.05 (NS)	-0.39**	-0.41**	-0.29*	-0.24 (NS)	-0.16 (NS)	-0.02 (NS)
Live	Gross Margin	€/LU	-0.57***	-0.54***	-0.51***	-0.57***	-0.54***	-0.03 (NS)	-0.38***
		€/ha	-0.15 (NS)	-0.32**	-0.16 (NS)	-0.20 (NS)	-0.30**	-0.30**	-0.35**
	Net Margin	€/LU	-0.46***	-0.62***	-0.39***	-0.57***	-0.46***	-0.42***	-0.61***
		€/ha	-0.13 (NS)	-0.22*	-0.15 (NS)	-0.08 (NS)	-0.26*	-0.23*	-0.27*
Mixed	Gross Margin	€/LU	-0.58***	-0.44***	-0.61***	-0.60***	-0.53***	-0.25*	-0.44***
		€/ha	-0.09 (NS)	-0.27**	-0.25*	-0.26**	-0.30**	-0.42***	-0.34***
	Net Margin	€/LU	-0.42***	-0.51***	-0.56***	-0.48***	-0.50***	-0.67***	-0.62**
		€/ha	-0.00 (NS)	-0.23*	-0.16 (NS)	-0.21*	-0.23*	-0.25*	-0.28**

Limitations of this study

While the results outlined have identified some statistically significant differences between production systems, certain limitations to this study are acknowledged. Farms in this study were selected as participants in a national knowledge transfer programme on the basis of farm location, having a herd size greater than the national average and a willingness to adopt new farm technologies. Thus, these farms were not directly representative of the national average for all of the technical and financial variables. However, this was also an important objective since the group of farms used in this current study had a main aim to increase farm profitability. Although the results shown in this study are an average of the 7 year period, Taylor and Crosson (2016) have shown the progressive improvement in profitability on these farms over the duration of the knowledge transfer programme.

All farms operated at a relatively similar level of production, particularly in relation to stocking rate. This reflects the selective nature of participation in the BETTER farm beef programme; however, this was not of particular interest since stocking rate has previously been established as a main factor effecting profitability (Fales *et al.*, 1995; Crosson *et al.*, 2014b).

Although the small sample size in this present study, 227 observations, is likely to contribute to a lack of significant differences for many variables, Milán *et al.* (2006) carried out survey work examining structural characteristics and typology of beef farms in Spain using a sample size of 130 observations. Furthermore, although using data from the National Farm Survey (Hennessy and Moran, 2015) rather than the Teagasc eProfit Monitor Analysis (Teagasc, 2016b) could facilitate a bigger sample size, there are restrictions associated with that data. The wide range of beef cattle production systems in Ireland, in addition to the number of combination systems with other farm enterprises, creates great difficulties in extracting technical and financial information solely attached to the beef enterprise. However, the records used in this study are known to be solely related to the suckler beef enterprise thus removing any external effects and allowing clear conclusions to be established.

A further limitation is the possibility of a confound existing between production system and location for farms in this study. However, this reflects the indigenous farm system locations in Ireland, whereby farms which sell progeny live either as weanlings or at older ages are typically found in the west and farms which retain ownership through to slaughter are more typical in the east.

Farm physical factors

The selection criteria for participation in the BETTER farms beef programme resulted in a larger farm size in this study relative to the national average and thus, land area, animal numbers and stocking rate were 12.7 ha, 69 LU and 1.1 LU/ha greater, respectively, than the average Irish suckler beef farm (Hennessy and Moran, 2015).

The larger farm size of Finishing and Mixed farms compared to Live farms reflects the regional diversification of farm systems in Ireland with Live farms predominantly found in the north-western region where farm size also tends to be smaller (CSO, 2012). As a direct result of smaller farm size with Live farms, but similar stocking rates, lower number of LU on Live farms is not surprising when compared to Finishing and Mixed farms. However, despite the differences noted in terms of farm size across system in this study, the correlation analysis suggests that farm size only had a small contributing factor on NM per ha. This is in agreement with (Veysset *et al.*, 2015), who found that increasing farm size did not produce economies of scale within beef systems but, in fact, resulted in increased fixed costs due to the need for further infrastructure and mechanisation. Furthermore, the negative impact of fixed costs in relation to net margin across all systems concurs with Finneran and Crosson (2013). This suggests that capital invested in farm infrastructure in order to increase farm size and production level was not justified by the additional gross output generated however further information as to the type of infrastructure purchased is required to fully justify this.

The correlation between stocking rate and concentrate costs per ha is supported by Finneran and Crosson (2013) who concluded that increasing stocking rate incurs additional expenditure and hence impedes profitability. In pasture based suckler beef systems it is important that stocking rate increases are supported by higher levels of grass utilisation rather than concentrate feeds owing to differences in feed costs. For example, in a systems modelling study Clarke and Crosson (2012), found that where increases in stocking rate are facilitated by higher quantities of grazed grass, although fertiliser costs increase, the additional carcass output produced had a positive effect on farm profitability. Due to differences in cost relativities, the additional concentrate costs incurred as a result of increased stocking rate would require a much greater increase in beef live weight output and GO, to result in greater profitability.

Considering calf-to-beef systems have been found to generate higher live weight output per ha than calf-to-weanling/store systems nationally (Teagasc, 2016b), it is unsurprising that similar results are found in the present study with Finishing farms obtaining higher live weight per ha that Live and Mixed systems. This is largely due to the relative inefficiencies of the suckler cow-calf phase, such as increased risk of disease and illness in young animals (More *et al.*, 2010) in addition to the unproductive maintenance costs of biologically inefficient beef cows (Crosson and McGee, 2012; Diskin and Kenny, 2014). However, on Finishing farms these inefficiencies are offset by the weanling-to-finish phase. While steer and heifer systems were found on many farms in this study, Finishing farms largely slaughtered male progeny as bulls. It has been shown that bulls achieve a higher live weight gain than steers (O'Riordan *et al.*, 2011; McMenamin *et al.*, 2015) and thus this may have further contributed to the higher live weight output produced on Finishing farms in this study. In addition to the higher beef live weight output, a higher price per kilogram was achieved by Finishing farms (2% and 5% greater than Live and Mixed farms, respectively) thus, explaining the greater GO value.

Production costs

Considering the varying nature of beef production systems, the lack of differences between systems in most of the production costs, particularly in terms of veterinary costs, is somewhat surprising. Considering that breeding and pre-weaned animals contribute to a greater proportion of the total LUs on Live farms, and noting that calf and calving related problems impact greatly on profitability, it is surprising that veterinary costs are not greater on Live than Finishing and Mixed farms, particularly on a per LU basis. Previous research by O'Shaughnessy *et al.* (2013) reported on a subset of 16 of the same farms as were included in this present study over a 2 year period (2009-2010), and found that dystocia effected approximately 70% of the herds, whilst calf pneumonia affected approximately 63%, therefore on a per LU basis, veterinary costs would be expected to be greater on Live farms. More *et al.* (2010) reported that the occurrence of diarrhoea and pneumonia in both pre- and post-weaned calves is the second most important health risk, after Bovine Viral Diarrhoea (BVD), to Irish beef farm productivity. Calf diarrhoea has been found to impact significantly on herd profitability due to increased mortality rates, treatment costs and reduced physical performance (Gunn and Stott, 1998). Whilst these health costs are still incurred on Finishing farms, the financial impact might be expected to be diluted by the number of mature, non-breeding animals on those farms. However, due to the focus on herd health in the knowledge transfer programme a number of factors may have prevented difference among systems in this study being detected; firstly, a herd health plan was implemented on all farms resulting in the use of vaccines in particular on reproductive and young animals, in addition the time frame of this study coincides with the establishment of the Bovine Viral Diarrhoea (BVD) eradication program by Animal Health Ireland (AHI, 2016; http://animalhealthireland.ie/?page_id=220) and finally, farms were participants in the Beef Technology Adoption Programme (BTAP; a discussion group programme funded by the Irish Department of Agriculture) thus enhancing their knowledge on herd health and how to prevent disease outbreak on farm.

Despite no significant differences being found among systems in relation to fertiliser costs, the greater numerical difference between fertiliser costs per ha and stocking rate on Live farms compared to Finishing and Mixed farms is probably attributable to regional effects. With Live farms largely located in the north-western region of the country where inclement weather conditions result in longer winter housing periods, silage conservation requirements are greater. In Ireland, recommended fertiliser application rates for grass silage production are much greater than that for grazed grass production (Teagasc, 2008), and thus incur greater fertiliser costs.

Higher concentrate costs per ha on Finishing systems compared to Live and Mixed systems is likely due to the higher concentrate input associated with the finishing phase, where cattle are offered more energy dense diets in order to reach a commercially acceptable carcass fat score (Drennan and McGee, 2009; Lenehan *et al.*, 2015; Marren *et al.*, 2015). Furthermore, the prevalence of bull beef systems on Finishing farms is likely to have resulted in predominantly, or solely, concentrate-based diets being fed during the final finishing period (O'Riordan *et al.*, 2011). Feeding high concentrate diets, in comparison to concentrate supplementation of grazed pasture or grass silage, increases feed costs (Crosson *et al.*, 2014b). However, the stronger negative correlation between concentrates as a percentage of GO and both GM and NM per LU on Finishing farms compared to Live and Mixed farms suggests that maximising the proportion of an animals' lifetime diet from grazed grass prior to the finishing phase is critical (Finneran *et al.*, 2012). This is in agreement with Crosson *et al.* (2014a) who concluded that optimising the contribution of grazed grass to the lifetime intake of cattle is important for the economic sustainability of pasture-based beef production systems.

Margin analysis

The absence of a significant difference between systems in terms of GM and NM per LU and per ha is surprising. This contradicts previous research modelling profitability of various beef production systems (Crosson *et al.*, 2014b; Crosson and McGee, 2015) reporting bull and steer finishing systems more profitable than weanling systems, thus indicating that production system has an effect on beef farm profitability. However, it must be borne in mind that this previous analysis was based on specific optimal or targeted conditions within systems and this is not necessarily the case at commercial farm level. The correlation analysis, however, identified that the main drivers of profitability varied across systems. Stocking rate was found to be the most influential factor of farm margin on Finishing and Mixed farms, which is in agreement with previous authors (Clarke and Crosson, 2012; Crosson *et al.*, 2014b), while beef live weight output per LU was a primary feature of profitability on Live farms. However, the correlations noted between beef live weight output and NM on a per ha basis on Live and Mixed farms was matched by the strength of the negative correlation between TC per kg output with NM on a per LU and per ha basis on these farms. This implies that while live weight output is an important driver of profitability, minimising costs per kg output produced is essential to attaining profit on Live and Mixed farms, more so than on Finishing farms. The larger negative effect of TC per kg output on GM and NM per ha and per LU on Live and Mixed farms compared to Finishing farms suggests that the significantly greater beef live weight output generated on Finishing farms was large enough to dilute the impact an increase in total costs would have on farm profitability.

The lack of significant difference in margin between systems is likely due to the homogeneity of the farms which is a function of the selection criteria for the participating farms. Furthermore, higher concentrate costs on Finishing farms are likely to have reduced the advantage from GO to NM on these farms despite a low impact of concentrate costs on NM being found in the correlations analysis. This is in agreement with previous findings (Crosson *et al.*, 2007) reporting a negative relationship between concentrate usage and farm net margin when concentrate intake is already optimised in a blueprint system, while Hennessy *et al.* (2012) showed that feed costs are a key factor affecting profitability on Irish beef farms.

Other variable costs were only seen to have a negative impact on NM on a per ha basis among Live farms suggesting that spending on miscellaneous items and inputs such as straw for bedding did not significantly affect farm profitability on Finishing and Mixed farms.

Furthermore, the stronger correlation between GO and NM per ha compared with GO and GM per ha on

Finishing farms suggests that GO is a good indicator of overall farm profitability. In contrast, GO and GM are more highly correlated than GO and NM per ha on Live and Mixed farms. This implies that intermediate costs, or total costs per kg output, had less of an impact on Finishing farms than those in the other two systems.

5. Conclusion

This study found that although greater beef live weight per ha and GO per LU and per ha was achieved on Finishing farms, compared to Live and Mixed farms, this was offset by the higher concentrate costs incurred and thus no difference in NM was observed across systems. Furthermore, economies of scale were not found in terms of profitability as greater farm size on Finishing farms did not lead to higher farm NM per ha or LU when compared with Live and Mixed farms. Physical output was identified as the main driver of profitability across systems in terms of stocking rate and beef live weight output per LU and per ha. However, it was established that while increasing physical performance of beef cattle in terms of beef live weight output per LU and per ha was key to increasing net margin, overall farm profitability was also effected by the level of expenditure incurred. Thus, minimising total costs per kg output is important in relation to maximising farm net margin.

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