SYSTEMS MODELLING

The Grange Beef Model: A mathematical model of Irish spring-calving suckler beef production systems

The aim of the Grange Beef Model is to specify a detailed and integrated set of management alternatives within the feeding and livestock specifications of Irish beef production systems and to identify optimal systems based on these alternatives and farm resources available. The model is deterministic, largely empirical and employs a single year steady-state design. The equations are specified in a Microsoft Excel spreadsheet and solved using the 'add-in' optimisation software "What's Best!". Budgets are formulated for each activity using the most recently available Irish data. These budgets assign a cost or revenue to each activity and based on these the model identifies the optimal beef production system. The objective function of the model maximises farm gross margin.

The model is constructed around a typical suckler beef cow herd based on spring-calving Limousin x (Limousin x Friesian) cows with animal groups based on the average animal within that group. Animal feed requirements and forage characteristics are based on well established biological functions. Animal performance and forage yield estimates are taken from experiments conducted at Grange Beef Research Centre. Diets for animal groups are based on a combination of grazing, grass silage, concentrate and maize silage, if available. All feeding activities are specified on a monthly basis to incorporate the seasonal variation in animal diets during the year.

A number of scenarios were investigated and are presented in Table 51. The first scenario is a base scenario and represents the conditions typically found on Irish beef farms in 2005. The second and third scenarios represent an increase and decrease in beef prices of ten percent. The fourth and fifth scenarios represent an increase and decrease of ten percent in concentrate price. The following two scenarios investigate varying herbage utilisation of grazing animals. Changes of fifteen percent from the base scenario of sixty-five percent are investigated. The integration of maize silage into beef production systems and its potential to increase gross margin is then investigated. The value of the Rural Environmental Protection Scheme (REPS) both in contributing to farm gross margin and in limiting N usage is studied by including a scenario where non-participation is assumed.

The main results are presented in Table 52 and indicate that changes in beef price can result in substantial adjustments to optimal beef production systems and leads to considerable variation in farm gross margins. A ten percent increase in beef price results in an intensification of production with regard to area farmed and animal numbers and a twenty-one percent increase in gross margin whereas a similar decrease in beef price leads to more extensive production and a fourteen percent decrease in gross margin. Increase in concentrate price of the magnitude modelled here, indicates little change in production and a marginal two percent decrease in gross margin relative to the base solution. However, where concentrate price decreases by ten percent, land area farmed and suckler beef cow numbers increase although gross margin only increases by three percent relative to the base scenario.

Table 51: Description of the nine scenarios investigated using the Grange Beef Model

		Beef price (c/kg)	Concentrate price (€/tDM)	Grass util (%)	Maize	REPS
Base[1]		290	200	65	No	Yes
Beef price (c/kg carcass)	Increase	319	200	65	No	Yes
	Decrease	261	200	65	No	Yes
Concentrate price (€/tDM)	Increase	290	220	65	No	Yes
	Decrease	290	180	65	No	Yes
Pasture utilisation (%)	Good	290	200	80	No	Yes
	Poor	290	200	50	No	Yes
Harvest maize		290	200	65	Yes	Yes
No REPS		290	200	65	No	No

[1]Base scenario: values reflect those found on farms in Ireland in 2005.

The more concentrate intensive bull beef finishing at sixteen months is preferred for male progeny with resulting increases in concentrate feeding levels. Results indicate that increases and decreases in grass utilisation rates of fifteen percent relative to the base scenario, results in a eleven percent increase and ten percent decrease in gross margin respectively. The harvesting of maize silage rather than grass silage also has the potential to increase gross margin by twenty percent relative to the base scenario. It is therefore, apparent that farmers can be proactive in combating falling gross margin by making judicious use of different production technologies. Relative to the non-REPS scenario, it is apparent that participation in REPS increases gross margin by twenty-three percent in the base solution. In addition, N usage is much lower due to the limits imposed by REPS. The increased gross margin in the base scenario of €7,400 is comparable with the REPS payment received of €7,300. This suggests that the reduction in enterprise output is more than offset by the REPS payment and reduced variable costs.

In conclusion, beef price had the largest effect on farm gross margin whilst the impact of concentrate price was relatively modest. However, these factors are largely outside farmers' control and therefore a number of scenarios were investigated to explore the potential of new or improved production technologies to improve gross margin. The two scenarios investigated, improved grass utilisation and harvesting maize increased margins by eleven and twenty percent respectively relative to the base scenario. Policy-makers are increasingly tying farm subsidies to the adoption of environmentally-friendly and societally-acceptable systems of production. This study has shown that one such program, REPS, was capable of delivering on the dual objectives of encouraging more extensive production and supporting farm incomes.

Table 52: Selected production results of the nine scenarios investigated using the Grange Beef Model

SCENARIO	Base	Beef price		Concentrate price		Grass utilisation		Harvest maize	No REPS
		Increase	Decrease	Increase	Decrease	Good	Poor		
Technical results									
Area farmed (ha)	40.0	60.6	40.0	40.0	54.2	56.2	40.0	52.1	50.6
Concentrates fed per cow (tDM)	0.8	0.8	0.8	0.8	1.2	0.8	0.9	0.3	0.8
Total N use (kgN.ha^{-1})	260.0	260.0	238.4	260.0	260.0	260.0	228.5	260.0	364.6
Suckler beef cow numbers	38.6	58.6	36.9	38.8	60.2	58.9	34.0	57.8	58.4
Males finished[1]	24St; 17.4	24St; 26.4	24St; 16.6	24St; 17.4	24St; 8.8, 16Bu; 18.3	24St; 26.5	24St; 11.8, 16Bu; 3.5	24St; 26.0	24St; 26.3
Females finished[2]	22Hf; 17.4	22Hf; 26.4	22Hf; 16.6	22Hf; 17.4	22Hf; 27.1	22Hf; 26.5	22Hf; 15.3	22Hf; 26.0	22Hf; 26.3
Financial results (€)									
Revenue	67,096	96,224	60,789	67,199	87,813	89,808	61,151	88,716	81,609
Direct costs	34,608	56,842	32,836	35,369	54,202	53,711	31,968	49,848	56,501
Gross margin	32,488	39,383	27,954	31,830	33,611	36,097	29,183	38,868	25,108
Gross margin relative to base		1.21	0.86	0.98	1.03	1.11	0.90	1.20	0.77

[1]24St, steers finished at 24 months; 16Bu, bulls finished at 16 months; [2]22Hf, heifers finished at 22 months.

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Investigating development options for Irish suckler beef farmers: a mathematical modelling approach

A number of alternatives are available to farmers who wish to expand their business. Some farmers will have surplus capacity both in terms of land and wintering facilities and will therefore be able to expand their beef enterprise without any associated capital development requirements. The majority of farms, however, will require upgrading of existing animal accommodation facilities to enable meaningful herd expansion. Low-cost accommodation options have recently been developed to facilitate cost-effective expansion of livestock enterprises.

Five farm development alternatives were investigated. These scenarios were designed to represent the primary options available to beef farmers and are presented in Table 53. ST is a static scenario and involves no change in the production system. Beef and cattle prices are taken from projections by FAPRI-Ireland. Input costs are subject to inflation at 2.8% per annum. DE is a de-stocking scenario whereby cow numbers were reduced from thirty-eight in 2005 to eighteen in 2007. EX, ES and EO are expansion scenarios and involve increases in cow numbers from thirty-eight in 2005 to fifty-eight in 2006. Suckler cow replacements were purchased as in-calf heifers at twenty-two months of age. For EX it was assumed that no capital development was required for this expansion i.e. surplus capacity existed in 2005, whereas for ES and EO capital development was required to facilitate this expansion. In the case of ES, capital development was by means of a slatted-floor shed whereas for EO, development was by means of an out-wintering pad for accommodation and an earth bank tank for slurry storage. Both of these development options provide accommodation for twenty additional adult animals.

Table 53: Expansion and herd culling and replacement policy

	2005	2006	2007-2012
Base (ST)			
Cow numbers	38	38	38
Replacement purchased	6	6	6
Cows culled	6	6	6
Destocking (DE)			
Cow numbers	38	28	18
Replacement heifers purchased	0	0	2
Cows culled	10	10	2
Expansion with no capital development[1] (EX)			
Cow numbers	38	58	58
Replacement heifers purchased	25	9	9
Cows culled	5	9	9
Expansion with development of SFS[2] (ES)			
Cow numbers	38	58	58
Replacement heifers purchased	25	9	9
Cows culled	5	9	9
Expansion with development of OWP[3] (EO)			
Cow numbers	38	58	58
Replacement heifers purchased	25	9	9
Cows culled	5	9	9

[1]Assumes surplus capacity in 2005; [2]Slatted-floor shed; [3]Out-wintering pad.

The key technical results are presented in Table 54. Production systems for all scenarios were based on finishing heifers at twenty months and finishing steers at twenty-two, twenty-six or twenty-eight months. Intake of grazed grass was high in all cases with grazed grass accounting for over sixty percent of the annual feed budget for all years in all scenarios and

over eighty percent for 2007 to 2012 in DE. N usage is low in all cases particularly for DE following de-stocking. In the expansion scenarios, N usage increases but still does not approach the 260kgN.ha^{-1} limit set by REPS specifications. In terms of labour requirements, the differences between the scenarios are pronounced. In the base, static scenario (ST) labour requirements are approximately 2,300 hours for all years. This is reduced by over thirty percent in the de-stocking scenario (DE) from 2008 to 2012. For the expansion scenarios (EX, ES and EO) the labour requirements are almost thirty percent greater than ST and forty-seven percent greater than DE from 2009 to 2012.

Table 54: Technical results of the five scenarios for the eight years modelled

	2005	2006	2007	2008	2009	2010	2011	2012
ST								
Grass fed per cow unit (tDM)	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.8
Silage fed per cow unit (tDM)	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Conc fed per cow unit (tDM)	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1
Total N used (kgN.ha^{-1})	110.6	111.4	111.4	111.4	111.4	111.5	111.8	111.8
Labour use (hrs)	2,322	2,329	2,329	2,329	2,329	2,328	2,328	2,328
DE								
Grass fed per cow unit (tDM)	4.7	5.2	6.1	5.7	5.4	5.4	5.4	5.6
Silage fed per cow unit (tDM)	1.8	1.7	1.4	1.2	1.1	1.1	1.1	1.1
Conc fed per cow unit (tDM)	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.1
Total N used (kgN.ha^{-1})	104.4	81.3	56.6	50.3	47.1	47.1	47.1	47.1
Labour use (hrs)	2,157	1,929	1,707	1,638	1,600	1,600	1,600	1,600
EX, ES and EO								
Grass fed per cow unit (tDM)	4.7	3.8	3.9	4.3	4.5	4.5	4.5	4.5
Silage fed per cow unit (tDM)	2.1	2.3	2.4	2.2	2.2	2.2	2.2	2.2
Conc fed per cow unit (tDM)	0.2	0.1	0.2	0.2	0.2	0.2	0.1	0.1
Total N used (kgN.ha^{-1})	130.4	166.0	176.9	201.1	213.8	213.8	217.9	217.9
Labour use (hrs)	2,843	2,918	3,000	3,021	3,045	3,045	3,033	3,033

Table 55 presents the revenues, costs and margins associated with the five scenarios investigated. The expansion scenarios have the highest revenues following 2006 when revenue is over €55,000 and rises to almost €90,000 in 2012. These scenarios have almost identical revenues illustrating the similarities of the production systems. DE has the lowest revenue after 2005 dropping to approximately €24,400 in 2009. ST is intermediate between DE and the three expansion scenarios in all years except 2005. As expected the expansion scenarios (EX, ES and EO) incurred the highest variable costs for all years, rising from approximately €30,000 in 2005 to almost €44,000 in 2012. DE had the lowest variable costs in all years and decreased by over €9,000 between 2005 and 2012. Again, ST was intermediate between DE and the expansion scenarios in terms of variable costs. Feed costs and animal expenses represented the main costs in all scenarios. The net margin figure illustrates the risk associated with expansion but also the potential financial rewards. DE initially has the highest farm margin of over €41,000 in 2005 due to income from de-stocking sales. This margin quickly drops as animal sales in subsequent years drop sharply. In contrast, EX, ES and EO have low margins initially, particularly in 2007 but subsequently margins increase sharply with an increase in animal sales and beef price to between €43,600 for ES and €46,200 for EX in 2012. As expected, of the three expansion scenarios, EX achieves higher margins followed by EO with ES the lowest of the three. ST has higher net margins than EX, ES and EO in 2005 and 2007, however in all other years the expansion scenarios have greater margins. In 2008 net margin is increased for the expansion scenarios due to a decrease in tax payable. This decrease is a result of a considerable reduction in net margin in 2007.

Table 55:Financial results of the five scenarios for the eight years modelled (all values in €)

	2005	2006	2007	2008	2009	2010	2011	2012
ST								
Revenue exc. SFP	46,028	37,987	40,510	42,486	46,115	50,082	55,445	61,138
Variable costs	28,063	27,688	27,701	27,740	27,803	27,887	27,990	28,110
Gross margin	17,966	10,299	12,809	14,746	18,313	22,194	27,455	33,028
SFP	32,500	31,675	30,608	29,328	28,111	26,956	25,858	24,815
Net margin	33,108	21,587	24,190	24,063	26,017	28,027	31,445	35,030
DE								
Revenue exc. SFP	53,827	35,836	25,262	25,428	24,370	28,253	30,718	33,325
Variable costs	27,460	23,650	19,965	18,982	18,393	18,323	18,273	18,241
Gross margin	26,367	12,185	5,296	6,446	5,976	9,930	12,445	15,084
SFP	32,500	31,675	30,608	29,328	28,111	26,956	25,858	24,815
Net margin	41,509	22,129	16,221	16,594	14,709	17,449	18,083	19,165
EX								
Revenue exc. SFP	50,861	55,390	49,608	63,864	66,123	72,175	80,363	89,052
Variable costs	28,970	36,362	37,901	40,933	42,533	42,834	43,149	43,467
Gross margin	21,891	19,027	11,707	22,931	23,590	29,341	37,214	45,585
SFP	32,500	31,675	30,608	29,328	28,111	26,956	25,858	24,815
Net margin	32,196	25,624	18,345	28,461	25,930	35,160	40,036	46,219
ES								
Revenue exc. SFP	50,861	55,388	49,606	63,860	66,118	72,169	80,356	89,044
Variable costs	30,109	37,477	38,993	41,840	43,394	43,652	43,926	44,206
Gross margin	20,751	17,912	10,612	22,019	22,723	28,517	36,429	44,838
SFP	32,500	31,675	30,608	29,328	28,111	26,956	25,858	24,815
Net margin	28,721	22,897	15,510	25,816	23,290	32,552	37,453	43,662
EO								
Revenue exc. SFP	50,861	55,389	49,607	63,862	66,120	72,172	80,359	89,048
Variable costs	29,311	36,701	38,234	41,197	42,783	43,071	43,374	43,681
Gross margin	21,550	18,688	11,373	22,665	23,338	29,101	36,985	45,367
SFP	32,500	31,675	30,608	29,328	28,111	26,956	25,858	24,815
Net margin	30,795	24,486	17,158	27,335	24,793	34,022	38,894	45,074

Discounted farm net margin and returns on investments (ROI) are presented in Table 56. Discounted net margin represents the net present value of future farm margins using a 5% discount rate. The expansion scenarios have the greatest discounted net margin with EX in particular over €20,000 greater than ST. DE has the lowest discounted net margin being almost €44,000 less than ST. The return on investments is presented for the expansion scenarios S3 to S5 and is the average additional profit earned relative to ST for each additional Euro invested in herd expansion, building development costs and working capital. The greatest ROI was for EX which had an ROI of 0.24.

Table 56: Total discounted farm net margin and return on investment

Scenario	Discounted net margin (€)	Return on investment
ST	201,735	
DE	158,139	
EX	223,017	0.24
ES	204,108	0.04
EO	214,982	0.15

In summary, results indicate that farmers will face a difficult period as the effects of implementation of the LA materialize. Farmers may adopt a "wait and see" approach whilst other farmers may chose to contract production. Farmers who elect to de-stock must be aware of its long term effects as they will be unable to capture the full effects of beef price increases predicted, particularly post 2007. Despite this, reduced labour requirements and the resulting opportunity to take up off-farm employment may make this alternative attractive to many farmers. Farmers who wish to expand should identify the associated costs and carefully prepare budgets to measure the impact of expansion.

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