The 82nd Annual Conference of the Agricultural Economics Society
Royal Agricultural College

31st March to 2nd April 2008

Modeling Rural Business Innovation: A Farm Diversification Application

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Abstract

This paper examines optimal business development strategies for rural firms given the specific characteristics of their rural business environment. An investigation of rural business strategy informs public policy formation by helping to determine how rural firms would react to changes in their market and policy environment. Moreover, an explicit rural business strategy analysis should help rural business managers and advisers to identify appropriate responses to changes in factors external to the business. A mathematical business optimisation model, that is set within a spatial market framework, has been developed. The model incorporates factors such as spatial market orientation and technology use, and identifies the business strategy that is optimal in different market and policy environments. The model is applied to a beef and sheep farm that can choose between selling livestock to meat processors or processing on-farm and selling direct to consumers. Model simulations reveal when it is optimal for the farm business to innovate in this way and how this decision is affected by changes in key parameters. The model's predictions are discussed in the context of local food supply, which is considered to have the benefits of being traceable, supporting the local economy and reducing food miles.

1. Introduction

A considerable body of research has already been undertaken to identify the factors that are responsible for geographical variations in business conduct and performance. The distinctive characteristic of the research reported in this paper is the explicit focus on the business strategies adopted by rural firms. The evolution of any business over a period of time is the result of an interaction between numerous internal and external factors. Since businesses have limited scope to shape the external environment, their success therefore depends especially on their internal ability to identify and respond to any external opportunities or threats. There are various aspects of the local business environment that are likely to influence the optimal development strategies of rural businesses. These include the nature of local product and input markets, the condition of local transport and communications infrastructure, the cost and availability of suitable premises, and the consequences of being in close proximity to the natural environment. The characteristics of these factors are not only determined by the prevailing market conditions but also by the type, level and implementation of public policy. Resource based firms such as farm businesses are almost always to be found in a rural location, therefore, their chosen business strategy results from a need to adapt to this rural location.

This paper examines optimal business development strategies for rural firms given the specific characteristics of their rural business environment. An investigation of rural business strategy informs public policy formation by helping to determine how rural firms would react to changes in their market and policy environment. An explicit rural business strategy analysis should also help rural business managers and advisers to identify appropriate responses to changes in factors external to the business. Moreover, from a theoretical perspective, it is recognized that modern economic geography models (i.e. new economic geography) have rudimentary business strategy underpinnings.

A mathematical business optimisation model, that is set within a spatial market framework, was developed. The model incorporates important areas of business strategy, such as, spatial market orientation and technology use. It identifies the business strategy that is optimal in different market and policy environments. The model is applied to a beef and sheep farm that has the opportunity to choose between selling livestock to meat processors versus processing on-farm and selling direct to consumers. The model incorporates activities relating to cattle rearing, sheep rearing, meat processing, meat marketing, land, labour, working capital, capital expenditure, and public policy. The technical coefficients for the models were calibrated using data contained in farm management and research publications. Consultation with industry experts enabled these coefficients to be further validated. Model solution identifies the profit maximising business strategy for that farm, given the initial set of farm resources and market conditions assumed. Model simulations reveal when it is optimal for the farm business to innovate and how this decision is affected by changes in key parameters.

It is claimed that rural firms successfully exploit niche markets, and can maintain a proactive product and market development strategy. These market strategies are attributed to rural firms having to cope with the limited size of local rural markets and the distance from the main centres of population, but also benefiting from a lower number of serious local competitors. It is important to recognize, however, that transport infrastructures not only enables trade from rural areas but also trade to rural areas; which inevitability exposes local rural markets to outside competition. These issues are discussed in this paper in the context of a diversified farm business supplying food directly to local markets. From a public policy perspective, local food products are considered to have the benefits of being more traceable, supporting the local rural economy and reducing food miles. Questions are therefore raised as to the possible role for government in encouraging the supply of these local foods.

2. Policy Issues

Innovation in rural areas requires greater attention from all levels of government, including the devolved administrations. Rural innovation is often either overlooked in regional innovation strategies, or only scantly mentioned in very specific contexts (such as Foot and Mouth Disease, or broadband projects). Central Government also tends to neglect rural areas as locations for innovation, focusing instead on cities and their adjacent regions (Mahroum et al., 2007). The problems of rural innovation are often found to be more acute in remote rural areas. For example, Patterson and Anderson (2003) in a marched plant study found that remote rural manufacturing plants followed a production-cost oriented non-local market strategy while accessible rural firms adopted a more innovation-oriented non-local market strategy. Moreover, while the attractiveness of the rural environment contributes to the perception of a higher quality of life in the countryside, it may be difficult however for government policy simultaneously to encourage the expansion of business activity while at the same time trying to maintain an attractive rural environment. That remote rural firms have been found to be more likely to cite environmental regulations as a significant constraint on business growth is clear evidence of this tension (Anderson et al., 2004).

The costs of transportation and communication also affect the relative competitiveness of rural businesses. Rural businesses incur relatively higher transaction costs in both their input and product markets. Interestingly, Anderson, et al. (2005) found that rural businesses are shown to be more innovative than urban businesses in the area of supply and distribution, which suggests that rural businesses are more active in the adoption of innovations that help alleviate the problems associated with distance. It may be possible to alleviate some of the problems of being distant from input markets, product markets, business services, or social events through the use of modern information technologies.

Innovation in the rural economy can now be observed in the most traditional of land-based industries such as agriculture. Many farmers are attempting to re-integrate themselves into regional and local markets by marketing value-added food products on the basis of their geographical identity. This may involve a switch to specific niche markets by selling higher-quality products embedded with information about product, process and place. These market niches sometimes involve more value-added processing at the farm or local level and often mean more direct contact between farmers and consumers, which can help to stimulate product and process innovation (Atterton and Ward, 2007). After reviewing a number of recent studies and comments, MacLoad (2008) identifies a range of benefits that farmers' markets, for example, may provide to consumers and the wider community. These include: (1) allowing access to fresh and nutritious produce, (2) providing quality assurance and traceability, (3) supporting the local economy, (4) encouraging more environmentally friendly production and marketing systems, and (5) aiding community development.

3. Methodology

In order to identify optimal farming strategies for Hill Beef and Sheep farms within Northern Ireland the representative farm modelling approach was adopted. This involves firstly the identification of groups of farms within the population with similar important characteristics, and secondly the creation of a representative farm model for each group (Hazell and Norton, 1986). The representative farm models can then be solved under differing pricing and policy assumptions to identify the optimal farming system for each group of homogeneous farms. Previous research efforts where the representative farm modelling approach was employed include Thomson and Buckwell (1979), Wallace and Moss (2002), and Gomez-Limon and Riesgo (2004).

3.1. Developing a Representative LFA Beef and Sheep Farm Model

Data from a random sample of 200 farm businesses within the target population were obtained through the undertaking of a face-to-face survey. The multivariate techniques of factor and cluster analysis were employed to identify, firstly, the underlying constructs that characterise these farm businesses, and secondly, the groupings of relatively homogeneous farms in terms of land, labour and enterprise characteristics. Factor analysis found significant relationships between land quality and enterprise mix, and also between beef production activities and labour profile. Cluster analysis identified ten distinct groups of farms, but allocated the majority of farms to four large clusters of relatively small farms. These small farms not only accounted for a large percentage of this sector's businesses (85.5%), but also of the sector's beef cows (59.5%), other cattle (59.2%) and breeding ewes (44.3%).

The representative farm model and results presented in this paper relate to one of the ten distinct LFA beef and sheep farm clusters discussed above (i.e. cluster/model seven). The rationale for presenting simulations from representative farm cluster/model seven is because this cluster/model represents medium sized LFA beef and sheep farms. These farms may be of a sufficient scale in terms of land, labour and working capital to successfully diversify into direct sales of their beef and lamb to consumers. Within this cluster, 92% of farms have beef cows with herds ranging between thirty and eighty-four cows, all farms have other cattle with numbers varying between forty-four and two hundred and thirty-five head and 46% of the farms have breeding ewes with flocks between twenty and two-hundred and eighty-five head.

Physical and financial assumptions of the different farming options incorporated within the model are based on information from farm data books, research publications, market reports, and communication with industry experts. The levels of owned farm resources assumed within the each representative farm model are based upon data obtained from the LFA beef and sheep survey undertaken. The model incorporates activities relating to cattle rearing, sheep rearing, livestock marketing, meat processing, meat marketing, land, labour, working capital, capital expenditure, and public policy. Upon solution each farm model selects the levels of these different options that formulate an overall profit maximising farm business strategy.

3.2 Cattle Rearing Activities

The models currently contain five beef cow options. The first option is a spring calving continental (i.e. Limousin cross Friesian) beef cow that is crossed with a charolais bull and housed during the winter period. The second option is an autumn calving continental (i.e. Limousin cross Friesian) beef cow that is crossed with a charolais bull and housed during the winter period. The third option is a spring calving traditional (i.e. Angus cross Friesian) beef cow that is crossed with an Angus sire and housed during the winter period. The fourth option is an autumn calving traditional (i.e. Angus cross Friesian) beef cow that is crossed with an Angus sire and housed during the winter period. The fifth option is a spring calving traditional (i.e. Angus cross Friesian) beef cow crossed with an Angus sire but in this instance winter management is outdoors. For these beef cow options an average calving date of 1st March for spring calving cows and 1st September for autumn calving cows are assumed.

Within the models there are four options relating to the rearing of replacement heifers. The first option is the rearing of spring calving continental type (i.e. Limousin cross) replacement heifers, the second option is the rearing of autumn calving continental type (i.e. Limousin cross) replacement heifers, the third option is the rearing of spring calving traditional type (i.e. Angus cross) replacement heifers and the fourth option is the rearing of autumn calving traditional type (i.e. Angus cross) replacement heifers. It is assumed under all options that replacement heifers are sourced from the dairy herd, housed during the winter period, and calve at 24 months.

Within the models options exist for the finishing of suckled calves produced by the various beef cow options. The finishing options are steers at 22, 23, and 24 months, and heifers at 19, 20, and 21 months. Housing in the winter period only is assumed for all the steer and heifer options.

The combination of beef cow and calf finishing options incorporated within the model enables the farm, if required, to supply standard beef (continental bred) and Aberdeen Angus branded beef in all 52 weeks of the year.

3.3 Sheep Rearing Options

Within the models there are four breeding sheep options. The first option relates to a Scottish Blackface ewe that is bred pure with a Scottish Blackface ram and lambs in April. The second option is a Scottish Blackface ewe crossed with a Texel ram that lambs in April. The third option is a crossbred ewe crossed with a Texel ram and again lambing in April. The fourth option is a crossbred ewe crossed with a Suffolk ram and lambing in January. It is assumed that Scottish Blackface ewes are out wintered and Crossbred ewes are housed. It is also assumed that for each breeding ewe option that any store lambs produced are weaned on the 1st September.

Within the models there are three options relating to the rearing of replacement ewe lambs. The first option is the rearing of home produced Scottish Blackface lambs that are assumed 16 kilograms halve weight. The second option is the rearing of purchased Scottish Blackface ewe lambs, which are assumed 14 kilograms halve weight. The third option is the rearing of crossbred ewe lambs. It is assumed that both Scottish Blackface ewe lamb options involve out-wintering, whereas the crossbred ewe lamb options involve housing. It is also assumed that crossbred ewe lambs are bred as ewe lambs, whereas Scottish Blackface ewe lambs are first bred as hogget's.

There are different options for the finishing of store lambs produced by the various breeding ewe systems. The first set of options relate to the finishing of store lambs indoors. It is assumed that lambs are initially grazed from the 1st September and then housed and fed concentrates ad-lib from the 1st November. The second set of options involves the finishing of lambs on grass supplemented with concentrates, with lambs entering these systems on the 1st September. The third set of options relate to the finishing of store lambs on grass alone, with lambs again entering these systems on the 1st September.

The combination of breeding ewe and lamb finishing options incorporated within the models enables the farm, if required, to supply standard (crossbred) lamb in all 52 weeks of the year. The model also enables the farm to produce Scottish Blackface branded lamb in the months of October, November, December, January, February, March and April.

3.4 Livestock Selling & Buying Options

Each model has options that allow the sale of finished cattle, finished lambs, suckled calves, store lambs, cull cows, cull bulls, cull ewes, and cull rams. Net revenue values for each type of finished prime cattle are calculated on model solution on the basis of assumed deadweight, beef price, and slaughter deductions. The assumed beef price for each animal is calculated from a reference base price (i.e. the average annual U3 steer beef price), by taking into consideration price seasonality, grade bonuses/penalties, and market bonuses. In all models Farm Quality Assured Status is assumed and therefore Farm Quality Assured prices are applied. The seasonal beef price variations within the models are based upon monthly U3 beef price variations that occurred over the period 2002-2005. The average observed deviations from U3 steer price for the different possible grades of steers and heifers during the years 2004 and 2005 are also used within the models to make the appropriate grading adjustment when calculating a beef price for each animal from the annual average U3 steer price assumed. Price bonuses for marketed Aberdeen Angus steers and heifers that meet market specifications are also taken into consideration. The bonuses available under the current Linden Aberdeen Angus Scheme are assumed within the models. These bonuses are comprised of a flat rate component and per kilo component, with levels of payments differing between suckler and dairy bred cattle. Finally, any deductions removed from animal value at slaughter are accounted for in the net revenue values of the finished animals. The slaughter deductions assumed in the models are Levy (LMC), Insurance, Grading Fee, Ard Co Levy (AgriSearch), W.D.C (Waste disposal and collection), Inspection Fee, Clipping, and OTM Additional Insurance. Net revenue values for the sale of cull cows are calculated on model solution on the basis of assumed deadweight, beef price, and slaughter deductions. The assumed beef price for each cull cow is calculated from a reference base price (i.e. the annual average O3 cow price), by taking into consideration price seasonality and grade bonuses/penalties. The annual average O3 cow price within the models is currently set at 72% of the annual average U3 steer price. The seasonal variation in cow price within the models is the same as that assumed for prime cattle. The slaughter deductions assumed applicable to cows are those relating to an over thirty months animal. The net revenue values for the sale of suckled calves and the purchase of drop calves are related to the annual average U3 steer price assumed in the models.

Net revenue values for the sale of finished lambs are calculated on model solution on the basis of carcass weight, deadweight price, and slaughter deductions. The deadweight price for each type of lamb or hogget is calculated from a reference base price (i.e. the annual average U3 lamb and hogget price), by accounting for grade and seasonal variations in price. The seasonal variations in quoted lamb and hogget prices from the average annual quoted lamb and hogget price for 1998-2005 are used within the models to adjust lamb and hogget sale prices for seasonality. The variations in lamb and hogget prices by carcass grade were obtained through the analysis of data for the season 2005/06. These grade price deviations are used in conjunction with the seasonal adjustments specified above to calculate prices for the different lamb and hogget types from the annual average U3 lamb and hogget price assumed within the models. Price bonuses for marketed Scottish Blackface lambs also included within the model. A slaughter deduction of £1 per head is assumed in calculating net revenues for finished lambs or hogget's. Net revenue values for sale of cull sheep and the sale of store lambs are related to the annual average U3 lamb and hogget price assumed in the models.

3.5 Animal diets

Within the models it is assumed that animal diets are a fixed combination of concentrates, straw, silage, and grazed grass. The different cattle feedstuffs options assumed are milk substitute, an 18% protein concentrate, a 17% protein concentrate, a 15% protein concentrate, and a barley/mineral mix. The different sheep feedstuff options assumed includes a breeding ewe concentrate and a lamb finishing mix.

Grassland management options within the models relate to annual fertiliser application rates of 0, 50, 100, 150, or 200 kilograms of nitrogen per hectare on arable or pasture land types. For some of the rough grazing the options is either to apply zero or a small amount of fertiliser. For the remainder of the rough grazing and all other remaining land types no fertiliser is assumed. In terms of conserved forage production within the models the options are either one or two cut silage. It is assumed that dry matter content of silage from both cuts is 22% with a D value of between 60-65. The total dry matter production is assumed at 5.5 tonnes from the 1 cut option and 8.4 tonnes from the 2 cut option.

3.6 Utilisation of Livestock Housing

Livestock housing options account for appropriate utilisation of available cubicle house, slatted cattle house, slatted sheep house, and non-specialist loose house resources. Cattle have the option of utilising available housing resources with the exception of specialist sheep housing, whereas sheep cannot use cubicle or slatted cattle housing. For the utilisation of loose housing straw bedding is assumed. Within each model options also exist that allow the provision of additional livestock housing and slurry storage through investment.

3.7 Overhead Costs for Beef and Sheep Systems.

Overhead costs applied directly to be beef and sheep options within the models are composed of contract work, machinery running costs, depreciation on machinery and buildings, land maintenance, building repairs, electricity, insurance and other miscellaneous overheads. The level of these costs associated with each beef and sheep option in the models were estimated from data for 149 LFA cattle and sheep farms which participated in the 2005 Farm Business Survey. This involved the running of a simple regression model on the dataset to identify what element of overhead costs varied with level of production and what proportion of overheads appeared to be truly fixed. The level of production was expressed in the regression model as the summation of total cow equivalents in the form of cattle and total cow equivalents in the form of sheep on these farms. Following this, the overhead costs associated with an average Northern Ireland beef cow (i.e. Limousin cross) on a per kilogram basis were determined. Using these estimates of overhead costs on a per kilogram basis the overhead costs for each of the different systems were calculated. These values were applied to each of the associated options within the models and the overhead costs that is totally independent of the level of production was deducted after model solution when calculating farm profit.

3.8 Capital Requirements of Beef and Sheep Systems

The capital requirements assumed for each livestock enterprise are composed of the initial purchase price and the variable cost associated with each enterprise until the point of first sale.

3.9 Leasing of Resources

Within each model options exist to either rent in or rent out land resources. Land resources are classified as arable, pasture, rough grazing, traditional hay meadow, species rich grassland, wetland, moorland, lowland raised bog, upland breeding wader site, woodland/scrub, or archaeological feature. Options for hiring in or hiring out labour resources are also present in each model. The costs of hiring in labour are assumed at the minimum agricultural wage rate, while the net revenue for hiring out labour resources is assumed equal to the minimum national wage rate. Within each model options also exist to allow the borrowing of working capital on either a current account or term loan. A borrowing limit is also assumed within each farm model. In addition the option of investing the businesses own working capital is available.

For each of the resources leased in, the supply functions faced by the business are given as linear functions in the following form:

$$PRS_i = ARS_i + BRS_i \, QRS_i \qquad \text{all } i$$

where: PRS_i is the leasing price of resource i supplied
QRS_i is the quantity of resource i leased in
$ARS_i > 0$ and $BRS_i > 0$

For each of the resources leased out, the demand functions faced by the business are given as linear functions in the following form:

$$PRD_i = ARD_i - BRD_i \, QRD_i \qquad \text{all } i$$

where: PRD_i is the leasing price of resource i demanded
QRD_i is the quantity of resource i leased out
$ARD_i > 0$ and $BRD_i > 0$

3.10 Meat processing, transportation and marketing costs

The average fixed costs (AFC_j) of processing, transportation and marketing meat products j relate to all processing, transportation and marketing costs except labour and raw material (i.e. beef and lamb) costs. These average fixed costs are assumed to take the following form:

$$AFC_j = (FC_j / QP_j) \qquad \text{all } _j$$

where : FC_j = fixed costs and QP_j = quantity processed, transported and marketed

The average variable costs (AVC_j) of processing, transportation and marketing meat products j relate to all processing, transportation and marketing costs except labour and raw material (i.e. beef and lamb) costs. These average variable costs are assumed to take the following form:

$$AVC_j = AVP_j + BVP_j \, QP_j \qquad \text{all } i$$

where: QP_j is quantity of meat products j processed, transported and marketed
$AVP_j > 0$ and $BVP_j > 0$

3.11 Consumer Demand

For each processed and marketed beef and lamb product, the consumer demand functions faced by the business are given as linear functions in the following form:

$$PPD_j = APD_j - BPD_j \, QPD_j \qquad \text{all } j$$

where: PPD_j = price of processed and marketed beef and lamb product j
QPD_j = quantity of processed and marketed beef and lamb product j demanded
$APD_j > 0$ and $BPD_j > 0$

3.12 Agricultural Policy

The various requirements of the Single Farm Payment (SFP), Countryside Management Scheme (CMS), and the Less Favoured Area Compensatory Allowance (LFACA) scheme are incorporated within the models. Therefore for scheme participants all farmed land will be subject to the management prescriptions that are specific to their habitat classification. The levels of payments assumed available under the CMS in the models are set at the levels available in 2007.

To qualify for LFACA payment, the stocking density must have been at least 0.2 LU/ha throughout the entire seven month period 1 April to 31 October. Eligible animals that count towards the stocking density calculation are suckler cows, heifers, breeding ewes, breeding female goats and breeding female farmed deer. The number of heifers that can count as eligible animals under the minimum stocking density limits must be no greater than 40% of the total number of suckler cows and heifers. Producers who have 25% or more of their eligible livestock units as suckler cows/heifers throughout the entire seven month period 1 April to 31 October will receive a bonus payment. Again the number of heifers that can count as eligible animals under the cattle bonus must be no greater than 40% of the total number of suckler cows and heifers. The annual area based payment is currently £40 for each hectare of SDA land and £20 for each hectare of DA land. The cattle bonus is currently paid as an additional payment of 25% of the area payment. Using Farm Business Survey data, an estimate was made of the likely SFP on the representative farm modeled, and was estimated to be £16,198 (including reference and area payments).

3.13 Own Resources Available

The levels of land, labour, working capital, and livestock housing resources assumed owned within the model were determined from the dataset of the LFA farm survey undertaken. Land resources owned are categorized as either arable, pasture, rough, species rich grassland, traditional hay meadow, wetland, moorland, lowland raised bog, upland breeding wader site, woodland/scrub, or archaeological feature. In line with Nitrate Directive regulations the maximum level of organic nitrate production per farm is assumed at 170 kilograms per hectare. Levels of the different types of land owned and the maximum organic nitrate production assumed on owned land on the representative farm is shown in table 1. Livestock housing resources available on each representative farm are categorised as cubicles, slatted cattle, slatted sheep, and loose housing. Additionally a quantity of slurry capacity is also available on each representative farm. The farmer and other family members that currently work on the farm are used to calculate potential labour availabilities. In line with Nix (2005) it is assumed that the farmer could provide 300 standard man-days per year, whereas other family members could provide 275 standard man-days per year. One standard man-day is equal to eight hours. The number of workers available on the farm and the total annual hours of labour hours assumed are also shown in table 1. The levels of own capital assumed available to finance livestock, working capital, and machinery are also shown in table 1. These levels of own capital available for each representative farm were estimated using data from 149 LFA Cattle and Sheep farms within the 2005 Farm Business Survey dataset. This involved the estimation of a regression model that expressed total owned working capital availabilities as a summation of cow equivalents in the form of cattle and cow equivalents in the form of sheep. Owned working capital availabilities were in the form of livestock, crops, machinery, feedstuffs, fertilisers, debtors, savings etc. Own working capital availabilities were then estimated from their cow equivalents cattle and cow equivalents sheep. Any additional resource requirements can only be met through the leasing of conacre, hiring of labour, investing in livestock housing, and borrowing capital.

4. Discussion of Results

The representative farm model outlined in section 3 was solved using the GAMS/BARON mathematical programming software package (Brooke et al., 1998; and GAMS Development Corporation, 2003). GAMS (General Algebraic Modeling System) is a matrix generator that was originally developed to assist economists at the World Bank in the quantitative analysis of economic policy questions. It allows modelers to generate many of the model parameters automatically, which enables model simulations to be conducted quickly and accurately. Optimization models created with GAMS must be solved with a programming algorithm, and the Branch-And-Reduce Optimization Navigator (BARON) was used in this case. While traditional nonlinear programming (NLP) and mixed-integer nonlinear programming (MINLP) algorithms are guaranteed to converge only under certain convexity assumptions, BARON implements deterministic global optimization algorithms of the branch-and-bound type that are guaranteed to provide global optima under fairly general assumptions. These include the availability of finite lower and upper bounds on the variables and their expressions in the NLP or MINLP to be solved.

Table 1: Own Resources in Representative Farm Model.

Land Owned		**Housing**	
Land Area Owned (ha)	53.09	Cubicle House Places (Cows)	36
		Slatted Cattle Accommodation (m2)	239
Breakdown of owned land		Loose Accommodation (m2)	67.47
Arable area (ha)	33.87	Slatted Sheep Accommodation (m2)	22.15
Pasture area (ha)	10.83	Slurry Storage Capacity (m2)	705
Rough Grazing area (ha) (includes common)	5.05		
Species Rich Grassland (ha)	0	**Owned Working Capital**	
Traditional Hay Meadows	0	CE Cattle	97.88
Wetland (ha)	0	CE Sheep	15.35
Moorland(ha)	2.78	Total OWC (£)	66,210
Lowland Raised bog (ha)	0		
Upland Breeding Wader Site (ha)	0.44	**Family Labour**	
Woodland/Scrub (ha)	0.10	Number of other full-time/part-time individuals working on farm other than respondent	0.692
Archaeological feature (ha)	0.02	Annual labour available from farmer (hrs) [1]	2400
		Annual labour available from other workers (hrs) [1]	1522
LFA Breakdown		Total annual labour available (hrs)	3922
SDA (% Total Land Farmed)	43.49		
DA (% Total Land Farmed)	52.76		
Non-LFA (% Total Land Farmed)	3.75		
Organic N Limit			
N Limit (kg)-owned land	9,025		

[1] Farm Management Pocketbook

Upon solution each representative farm model identifies the overall farming system that achieves the maximum profit under the base assumptions. Following this, the models can be solved under alternative scenarios, where the assumptions relating to product prices, input prices, borrowing constraints, off-farm wage rates, levels of farm payments etc. are subjected to sensitivity analysis. Within these simulations the assumptions were made that the land must be maintained in good agricultural condition for Single Farm Payment purposes. Additionally it is assumed that the farmer participates in either the Environmentally Sensitive Area Scheme or the Countryside Management Scheme (whichever is relevant). All model results reported below assume (1) an annual average U3 steer price of £2.00 per kg, and (2) an annual average U3 lamb and hogget price of £2.50 per kg. The farm business profit figures reported in Tables 2, 3 and 4 includes profit/income generated from farming activities, direct consumer sales, the CSM/ ESA schemes, and the LFACA scheme.

4.1 Spatial Markets

Table 2 illustrates how the optimal strategy of the business is influenced by changes in the relative size of the local rural market. The local rural market was calibrated to be smaller, and then larger, than that assumed in the base case. It is clear from Table 2 that the size of the local market is crucial to the economic viability of farmer direct sales to the consumer. A sufficiently large output is required in order to lower average fixed costs to a level where the farm supplier of beef and lamb is competitive in the market. Strategies that farm businesses could adopt to alleviate this problem include moving the business to a location with larger local markets, increasing advertising in order to expand market size, and using the internet to launch into more distant markets. Government could also help by promoting local food in order to raise public awareness of the advantages of buying local produce. Better labeling of food would also help consumers to make informed choices about how their food was produced and where it came from.

Table 2 Model Simulations: Spatial Markets

	Base Model[1]	Small Local Market[2]	Large Local Market[3]
Farm Enterprises			
Beef Cows (hd)	35	9	60
Other Cattle (hd)	70	18	117
Breeding Ewes (hd)	56	158	49
Other Sheep (hd)	23	40	20
Livestock Sales			
Store cattle (hd)	0	0	0
Cull cows (hd)	5	1	8
Finished cattle (hd)	0	8	0
Store lambs (hd)	3	100	0
Cull ewes (hd)	11	32	9
Finished lambs (hd)	0	146	0
Meat Processing			
Cattle processed (hd)	33	0	56
Lambs processed (hd)	66	0	69
Total meat processed (kg)	10915	0	17074
Direct Consumer Sales			
Beef – standard (kg)	4290	0	4880
Beef – AA (kg)	5249	0	10759
Lamb – standard (kg)	1206	0	1435
Lamb – SBF (kg)	170	0	0
Resource Use			
Total land farmed (ha)	105	69	153
Land leased in (ha)	52	16	100
Labour hired (hrs)	0	0	0
Off-farm employment (hrs)	1635	2480	390
Capital borrowed (£)	0	0	18040
Capital invested (£)	12027	24914	0
Farm Income			
Farm business profit (loss)	8343	2606	28970
Off-farm employment (£)	8747	13268	2086
Capital invested (£)	391	810	0
Single Farm Payment (£)	16198	16198	16198
Total Farm Income (£)	33679	32882	47254

Note:

1. Retail demand functions calibrated at quantities: beef markets = 500kg, lamb markets = 200kg

2. Retail demand functions calibrated at quantities: beef markets = 100kg, lamb markets = 40kg

3. Retail demand functions calibrated at quantities: beef markets = 2500kg, lamb markets = 1000kg

4.2 The Fixed Costs of Direct Consumer Sales

Table 3 illustrates how the optimal strategy of the business is influenced by changes in the fixed costs associated with the processing, transportation and marketing of beef and lamb direct to consumers. Table 3 indicates that the level of fixed costs required to commence direct selling of a farm's beef and lamb direct to consumers has a critical influence on whether the venture is likely to be financially successful. If fixed costs are too high, then local market demand may not be large enough to allow average fixed costs to fall to a level that enables the farm's product to be profitable at competitive market prices. The fixed costs of selling meat direct to consumers would include, for example, buildings, equipment, vehicles, insurance and minimum levels of marketing activities. Farm businesses could attempt to lower these costs by, for example, obtaining capital grants and also by aiming to more efficient in carrying out necessary administrative tasks. Equally, government can help by continuing to provide financial assistance in the form of grants and also by ensuring that regulation of these diversified farm businesses is effective and efficient.

4.3 The Opportunity Cost of Farm Family Labour

Table 4 illustrates how optimal business strategy is influenced by the opportunity cost of the farm family labour. In making the decision as to whether a farm business should commence marketing its beef and lamb direct to consumers the farm family should consider if their available labour resources would be better employed in off-farm employment. Table 4 indicates that the opportunity cost of farm family labour has a significant impact on the decision to proceed with the enterprise or not. This is particularly important as the type of individual who has the skills to successfully operate a farm retail operation is likely to be able to command wages significantly above minimum wage levels. Also remember that the meat processing sector operates in a very tough commercial environment. In order to improve returns to labour inputs in the enterprise farmers could attempt to produce higher value products and also make efforts to improve labour efficiency. From the perspective of public policy, clearly education and training will be important in helping to raise skills levels. Product quality and labour productivity could also be improved through publicly funded research and development.

Table 3 Model Simulations: Fixed Costs of Direct Sales

	Base model FC's = £18,000[1]	**Direct sales FC's = £8,000[1]**	**Direct sales FC's = £28,000[1]**
Farm Enterprises			
Beef Cows (hd)	35	35	9
Other Cattle (hd)	70	70	18
Breeding Ewes (hd)	56	56	158
Other Sheep (hd)	23	23	40
Livestock Sales			
Store cattle (hd)	0	0	0
Cull cows (hd)	5	5	1
Finished cattle (hd)	0	0	8
Store lambs (hd)	3	3	100
Cull ewes (hd)	11	11	32
Finished lambs (hd)	0	0	146
Meat Processing			
Cattle processed (hd)	33	33	0
Lambs processed (hd)	66	66	0
Total meat processed (kg)	10915	10915	0
Direct Consumer Sales			
Beef – standard (kg)	4290	4290	0
Beef – AA (kg)	5249	5249	0
Lamb – standard (kg)	1206	1206	0
Lamb – SBF (kg)	170	170	0
Resource Use			
Total land farmed (ha)	105	105	69
Land leased in (ha)	52	52	16
Labour hired (hrs)	0	0	0
Off-farm employment (hrs)	1635	1635	2480
Capital borrowed (£)	0	0	0
Capital invested (£)	12027	12027	24914
Farm Income			
Farm business profit (loss)	8343	18343	2606
Off-farm employment (£)	8747	8747	13268
Capital invested (£)	391	391	810
Single Farm Payment (£)	16198	16198	16198
Total Farm Income (£)	33679	43679	32882

Note:

1. Annual fixed costs of direct consumer sales (processing, transportation, marketing etc)

Table 4 Model Simulations: Opportunity Cost of Farm Family Labour

	Base Model[1]	Off-farm Employment @£10.70/hr[2]	Off-farm Employment @£16.05/hr[3]
Farm Enterprises			
Beef Cows (hd)	35	9	26
Other Cattle (hd)	70	10	29
Breeding Ewes (hd)	56	150	46
Other Sheep (hd)	23	37	11
Livestock Sales			
Store cattle (hd)	0	4	12
Cull cows (hd)	5	1	4
Finished cattle (hd)	0	4	12
Store lambs (hd)	3	94	29
Cull ewes (hd)	11	30	9
Finished lambs (hd)	0	138	43
Meat Processing			
Cattle processed (hd)	33	0	0
Lambs processed (hd)	66	0	0
Total meat processed (kg)	10915	0	0
Direct Consumer Sales			
Beef – standard (kg)	4290	0	0
Beef – AA (kg)	5249	0	0
Lamb – standard (kg)	1206	0	0
Lamb – SBF (kg)	170	0	0
Resource Use			
Total land farmed (ha)	105	53	53
Land leased in (ha)	52	0	0
Labour hired (hrs)	0	0	0
Off-farm employment (hrs)	1635	2608	2822
Capital borrowed (£)	0	0	0
Capital invested (£)	12027	27749	30088
Farm Income			
Farm business profit (loss)	8343	1664	(1325)
Off-farm employment (£)	8747	27906	45293
Capital invested (£)	391	902	978
Single Farm Payment (£)	16198	16198	16198
Total Farm Income (£)	33679	46670	61144

Note:

1. Farm family labour can be employed off-farm at National Minimum Wage (assumed to be £5.35/hr).

2. Farm family labour can be employed off-farm at twice the National Minimum Wage

3. Farm family labour can be employed off-farm at three times the National Minimum Wage

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