An Examination of the Implications of Milk Quota Reform on the Viability and Productivity of Dairy Farming in Ireland

Project Leader & Editor

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Contributors

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CHAPTER 1

Rationale for Undertaking the Research

This research proposal was initially developed in 2005. At the time, the Irish dairy farming sector was undergoing a period of substantial change. The Medium Term Review (MTR) of the CAP, agreed in 2003, was introduced in 2005. This policy agreement allowed for the decoupling of all direct payments from production as well as agreeing a reduction in the intervention prices for butter and skim milk powder. Ex-ante analyses of the policy proposal predicted that the policy would expedite the process of structural change in dairy farming, with an increased number of farmers likely to exit the sector following the milk price reductions. These studies suggested that the future viability of dairy farming, following the MTR, would be largely dependent on the efficient transfer of resources between exiting farmers and those wishing to expand production.

Up to this time, milk quota transfer between farmers in Ireland operated exclusively through the milk quota restructuring scheme. Following the policy reform, officials at the Department of Agriculture, in conjunction with the main industry stakeholders, were considering changing the structures governing the transfer of milk quota between farmers. The importance of reviewing the milk quota transfer mechanism was acknowledged by the Agri-Vision 2015 committee. The Agri-Vision 2015 report, published in 2005, recommended that the reallocation of quota between farmers needed to be made more flexible and more responsive to farmers' needs. The report called for an examination of the current quota reallocation process, with a view to ensuring that it was not in conflict with the emergence of a competitive low cost milk production structure.

It was in this context that the project proposal was developed. The aim of the project was to produce quality, scientific based policy advice on the most efficient means for the transfer of milk quota between dairy farmers. The main objective of the project was to identify milk quota transfer mechanisms that would ensure the viability of the maximum number of farmers in Ireland while still supporting an internationally competitive agricultural sector.

During the course of the project the Irish Department of Agriculture introduced a new milk quota transfer scheme. The milk quota exchange scheme was launched in November 2006. At this stage the objectives of the project were altered to be more policy relevant. Rather than exploring the efficiency of various milk quota transfer models, the aim of the project was redirected to explore the efficiency of the scheme as it was operated in Ireland. The rationale for this change was to provide relevant and timely feedback to policy makers on the operation of the new scheme.

While the MTR agreement guaranteed the continuation of the EU milk quota regime until 2014/15, it also made provisions for a review of the milk quota system to be conducted in 2008. Clearly any changes to EU milk quota policy would have implications for farmers in Ireland. A second objective of this project was to explore some policy scenarios that may transpire from the milk quota review and to estimate the implications for farmers in Ireland.

2. Research Approach

The main objectives of the project can be broken down into three tasks and each task required a different research approach. The tasks and research approaches adopted were as follows;

(1) To examine the efficiency of the milk quota exchange scheme

This objective here was to examine the operation of the milk quota exchange scheme in Ireland and to explore the implications for sector efficiency. To this end, an optimisation model was developed to estimate the economic value of quota. National Farm Survey (NFS) data for Ireland and FAPRI-Ireland price projections were used to estimate the economic value of quota for each dairy farmer in the survey. The optimisation model used a linear programming framework where farm profit was maximized subject to the physical and financial constraints on the farm and the policy related constraints, such as the milk quota. The economic value of quota was estimated as the sum of the discounted stream of annual cashflows between the current period and the period when quota is abolished. Individual economic values were then aggregated to derive quota sale and purchase curves. The intersection of the supply and demand curves indicated the equilibrium milk quota value. The model was run under a number of scenarios, (i) where quotas were only allowed to trade regionally so as to reflect the ring-fencing system and (ii) where quotas were allowed to trade nationally. Through the derivation of sectoral cumulative cost curves it is possible to estimate the impact of regionalising quota trade on sector efficiency.

(2) To examine the implications of a reform to the EU milk quota regime

The FAPRI-Ireland partnership group of models were used to examine the implications of changes to EU milk quota policy. The policy reform was first examined at an aggregate level using the Ireland and EU models. There are econometrically estimated partial equilibrium models of the agriculture sector that are solved under various policy scenarios to produce estimates of changes in the prices of inputs and outputs. These price and cost projections are then used in the FAPRI-Ireland farm level models to examine the implications of the policy change for farmers. First a set of profit maximising linear programming models are solved annually for each farm participating in the NFS. Farm net margin is maximised subject to physical, financial and policy related constraints. The LP models are then supplemented with three exogenous models of farmer behaviour. The first model estimates the effect of policy on the rate of entry and exit from farming and thus farm numbers by developing a multinomial logit model of farmer retirement and succession decisions. Second, the effect of policy on the number of part-time farmers is estimated using a two-step sample selected corrected labour supply model and finally the decision to exit dairy production is estimated using a profit simulation model.

(3) To examine the implications of milk quota reform for farm production systems

The Moorepark Dairy Systems model (MDSM) was used to estimate the effect of a change in policy or milk quota transfer mechanisms on dairy farm production practices and overall farm profitability. The MDSM is a stochastic budgetary simulation model formulated within a Microsoft Excel spreadsheet. The model integrates animal inventory and valuation, milk supply, feed requirement, land and labour utilisation and economic analysis. Variable costs (fertiliser, contractor charges, medical and veterinarian, AI, silage, reseeding), fixed costs (machinery, maintenance and running costs, farm maintenance, car, telephone, electricity and insurance) and prices (calf, milk and cow) are based on current prices. The feeds offered (grass, grass silage and concentrate) are determined by the MDSM meeting the net energy requirement for milk production, maintenance and live-weight change. The model was estimated under different milk quota scenarios to investigate how the optimal milk production system changes under each scenario.

3. Research Achievements

The main research results or achievements can be summarised under the three objectives outlined above.

(1) Summary results on the efficiency of the milk quota exchange scheme

The milk quota exchange scheme as it currently operates was simulated during the course of the project. To simulate the effect of ring-fencing, four regional markets for milk quota were estimated; the Border Midlands West region, the Southwest region, the East region and the South region. The results showed that the economic value of quota varied across the four regions, from 25 cent per litre (CPL) in BMW, 30.3 CPL in the East, 39.5CPL in the Southwest and 36CPL in the south. The results showed that if ring-fencing was abolished and quotas could trade nationally, the economic value of milk quota would be 35CPL. The implication is that if Ireland shifted to national milk quota trade, quota would move out of the BMW and East regions and into the South West. Results showed that the shift from a ring-fenced to a national quota exchange had only a negligible effect on total farm numbers, with numbers falling only 1.5 percent faster when quota is traded nationally. However, farm numbers declined substantially faster in the BMW and East regions when quota is traded nationally.

The implications for sector efficiency were measured using sector cumulative cost curves developed under the two scenarios. Under national trade the aggregate milk supply would be produced at a cost of €818.7 million. Under the regional scenario the cost was estimated at €845.9 million, approximately €27million or 3 percent higher. It follows then that the practice of ring-fencing quota trade to particular regions introduces an inefficiency of approximately €27 million.

The results of the model were also compared to actual milk quota trade prices garnered from the first three exchanges. The results showed, as would be expected through economic theory, that there is a divergence between the value of quota and its trade price and that this divergence is more pronounced in some regions. In particular, quota is very overpriced in co-operatives in the south and east meaning that farmers are overpaying for milk quota in these regions.

(2) Summary results on the implications of a reform to the EU milk quota regime

Two milk quota expansion scenarios were analysed. Scenario 1 involved a 3 percent increase in the Irish national milk quota in 2008/09, while Scenario 2 involved a series of 3 percent increases from 2008 to 2014 totalling 21percent. Both scenarios assumed quota abolition in 2015. The effects of the scenarios were measured against a baseline which assumed the EU milk quota continued unchanged over the period. Results showed that milk prices would decline under the two milk quota expansion scenarios. By 2014 milk prices would be 4 percent lower under Scenario 1 and 7 percent lower under Scenario 2.

Under Scenario 1 the results showed that, up to the point of quota elimination, the milk quota increase would be insufficient to offset the milk price decline and as a consequence farmers would be worse off. The results for Scenario 2 were more positive. The milk quota increases were sufficient to off set the milk price decline and as a result the typical producer increasing production by 3 percent per year would be better off than in the baseline. However, there are winners and losers under this Scenario. Farmers operating in regions with lower than average milk quota exchange prices would be better off under existing policy, as they have access to cheap quota and milk prices are higher. In general the results support that the Irish dairy sector would benefit from larger and faster increases in the milk quota.

(3) Summary results on the implications for production systems

When milk quota is limiting, farm profit is maximised by minimising production costs. When the quota is no longer limiting, most farms will find that land is the most limiting resource. In this case, the optimal production system involves maximising the utilisation of grass while at the same time minimising the requirement for purchased feed. The Moorepark Dairy Systems model was run to determine the optimum system of production under the various milk quota scenarios. The results suggest that when milk quota is no longer binding, dairy farmers will maximise profit by increasing the stocking rate on the grazing platform. The current optimal stocking rate around the existing grazing platform is 1.8 cows per hectare. The analysis showed that this optimal would increase to 2.8 cows per hectare if there was no quota constraint on production. Results also showed that when the milk quota constrains production, the optimal mean calving date is mid to late February. When the quota constraint is relaxed the optimal calving date shifts to mid to early February. An important factor affecting the optimal calving date is the compactness of calving. Where 50 percent of cows are calved in 2 weeks and 90 percent are calved in 6 weeks, these calving dates should be later by one week in order to have good synchrony between supply and demand.

The research on milk quota expansion/abolition shows that the optimal production system would change in the following way;

- The mean calving date would be earlier, Feb 15th rather than March 15th
- Stocking rates would increase from 1.8 cows per hectare to 2.8
- Strategic use of supplementation to aid grassland management
- Increased focus on genetic selection of animals based on the Economic Breeding Index (EBI)

4. Impact of the Research

The main research results have been outlined above. The dissemination of results and the impact of the research can be summarised under three main headings;

Policy Advice

The main objective of this research project was to provide scientific advice to policy makers on the effect of policy proposals/policy reform. Policy advice constituted one of the major outputs or impact factors for the project. The EU milk quota regime scenarios that were analysed were selected in consultation with policy officials from the Department of Agriculture. They were selected on the basis of being a possible outcome of the CAP Health Check, which was ongoing at the time. The scenarios were analysed and results were made available to policy officials and other industry stakeholders at a public conference. The main impact of this research was the provision of advice/information to policy makers in a timely fashion, i.e. while negotiations were still ongoing.

The other major piece of policy analysis conducted during the course of the project was the evaluation of the milk quota exchange scheme. Again at the request of policy officials in the Department of Agriculture, the operation of the scheme was evaluated with a view to estimating its efficiency and the implications for farmers' viability. The results of this analysis are outlined above and were also presented to policy makers at the time. This allowed those involved in formulating the milk quota exchange regulations to act on the information if they wished.

Following the completion of these two pieces of policy analyses, members of the research team were invited to address the Minister's Dairy Stakeholder forum, this is a high level meeting of industry stakeholders convened by the Minister.

Stakeholder Interaction

Dissemination of results to stakeholders constituted another major output or impact factor for the project. Some of the models developed during the course of the project produced results that were of direct relevance to farmers. In particular, the Moorepark model was used to estimate the maximum affordable price farmers should bid for quota.

This information was disseminated to farmers at a very opportune time, i.e. just before the first milk quota exchange took place. These meetings, of which there were 15 around the country, provided farmers with valuable information on how the milk quota exchange would work and on what prices they should consider bidding. This activity contributed to the success of the first milk quota exchange scheme.

The analysis of the implications of EU milk quota reform and the implications for the optimal production system were also disseminated to farmers. Presentations were made at the Teagasc National dairy conference and a number of popular articles were published. Again the major impact of the research in this regard was to minimise the information gap that existed for stakeholders on what the future may hold with respect to milk quota policy.

Scientific Publications

A number of academic peer reviewed journal articles were published during the course of the project. These papers showcase the methodologies employed in the research rather than the actual results. The main objective is to ensure quality control in relation to the methods used in the research. Another major outcome or impact of this activity is to contribute to the intellectual/scientific understanding of how quotas operate.

5. Exploitation of the Research

The objective of this project was to conduct research on a number of issues pertaining to milk quota policy with a view to providing evidence based policy advice to government. As such, the objectives of the project were not to generate any new technology or intellectual property that could be adopted by industry.

The recommendations arising from this research have been presented to officials at the Department of Agriculture, to officials at Teagasc and a large number of industry stakeholders at conferences and various other fora. The policy recommendations have been well aired and made publicly available. However, give the slow pace at which policy making occurs, it is as yet difficult to comment on whether the information produced by this project has been exploited.

6. Summary of Research Outputs

(a) Intellectual Property applications/licences/patents
N/A

(b) Innovations adopted by industry
N/A

(c) Number of companies in receipt of information
N/A

(d) Outcomes with economic potential
N/A

(e) Outcomes with national/ policy/social/environmental potential
N/A

(f) Peer-reviewed publications, International Journal/Book chapters.

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Smyth, P., Butler, A.M. and Hennessy (2008). Explaining the variability in the Economic Performance of Irish Dairy Farmers 1998-2006. Journal of International Farm Management. Vol. 4 (4) 1-18.

(g) Scientific abstracts or articles including those presented at conferences

Hennessy, T. (2007). CAP Health Check Analysis: Farm Level Implications of EU Milk Quota Expansion. Proceedings of the FAPRI-Ireland Outlook 2007 Conference, Dublin.

Breen J, Hennessy T and Thorne F (2007). FAPRI-Ireland Baseline 2007: Farm Level Analysis. Proceedings of the FAPRI-Ireland Outlook 2007 Conference, Dublin.

Donnellan, T. and Hennessy, T. (2007). The Effect of Milk Quota Expansion on EU/Irish Production. Proceedings of the Teagasc National Dairy Conference, Kilkenny, November 21st.

Donnellan, T. and Hennessy, T. (2007). The Effect of Milk Quota Expansion on EU/Irish Production. Proceedings of the Teagasc National Dairy Conference, Castlebar, November 22nd.

Hennessy, T. (2007). Prospects for Dairy Expansion. Invited Paper to the Irish Co-operative Organisation Society's Annual Conference. CityWest Hotel, Dublin. November 2007.

Shrestha. S and Hennessy. T (2007) Simulating a market for milk quota under policy reforms: an Irish study. Paper presented at the annual British Agricultural Economics Society, Reading April 2007.

Shrestha. S and Hennessy. T (2007) Simulating a regional market for milk quota. Paper presented at the Agricultural Research Forum.

Shrestha. S., Hennessy. T, Shallo, L., and Dilon, P. (2006) Estimating the Supply and Demand of Milk Quota in Ireland. Rural Economy Working Paper Series, WPRE19– www.tnet.teagasc.ie/rerc/workingpapers.

Shalloo L. and Dillon P. (2006). Is milk quota Worthless? New Vision for the Irish Dairy Industry. Teagasc National Dairy Conference.Wednesday 15th of November, South Court Hotel Limerick, Page 9-15.

Shalloo, L., O'Donnell, S. and Horan, B. (2007). Milk production after quotas. Teagasc IE p. 24-28 ISSN 1 84170 486 5 13711

Shalloo, L., O'Donnell, S. and Horan, B. (2007). Profitable dairying in an increased EU milk quota scenario. Exploiting the Freedom to Milk. In Proceedings of the Teagasc National Dairy Conference. Wednesday and Thursday 21th and 22nd of November, Lyrath Hotel Kilkenny and Breaffy House Hotel Castlebar, Page 20-44.

French, P, Shalloo, L., Donworth, J. and Horan, B. (2007). A roadmap for high profit dairy systems in the future. Teagasc IE p. 5-14 ISSN 1 84170 486 5 13710

Smyth, P., Butler, A. and Hennessy, T. (2008) The economics of dairy farming in Ireland. Paper presented at the AES Conference, Cirencester, England

Hennessy T, Shrestha, S. Shalloo L and Wallace, M (2008). The Inefficiencies of Regionalised Trade of Milk Quota. Rural Economocy Working Paper Series.

(h) National Report

Shrestha. S., Hennessy. T, Shalloo, L., and Dilon, P. (2006) Estimating the Supply and Demand of Milk Quota in Ireland. Discussion Paper Submitted to the Irish Department of Agriculture.

Shalloo L. and Dillon P. (2006). Milk quota pricing and policy in a decoupled milk price environment. Document submitted to the Department of Agriculture in May 2006.

(i) Popular non-scientific publications

N/A

(j) Workshops/seminars/ open days at which results were presented (excluding those in (g))

Hennessy, T. (2007). Competitiveness at the farm level: preparing for a freer dairy market. Presentation to the Minister's National Dairy Forum. Dublin July 26th

Hennessy, T. (2007). Update on milk quota transfer modelling. Presentation to Department of Agriculture Officials. DAF Offices, Dublin. July 17th

Donnellan, T, Hennessy, T and Thorne, F, (2007) World Trade Talks and the EU Milk Quota Regime – The Time for Reform? Paper presented at the annual British Agricultural Economics Society, Reading April 2007.

Stakeholders' Consultation on the Future of Milk Quotas – Held in Moorepark on November 8th.

Proceedings of Stakeholders' Consultation

Hennessy T (2006) Prospects for the Irish Dairy Sector. Presentation made to the Stakeholders' Consultation.

Shalloo L (2006) What to pay for milk quota? Presentation made at 15 farm meetings nationwide in the October November period.

CHAPTER 2

ECONOMICS OF DAIRY FARMING IN IRELAND

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2.1. Introduction

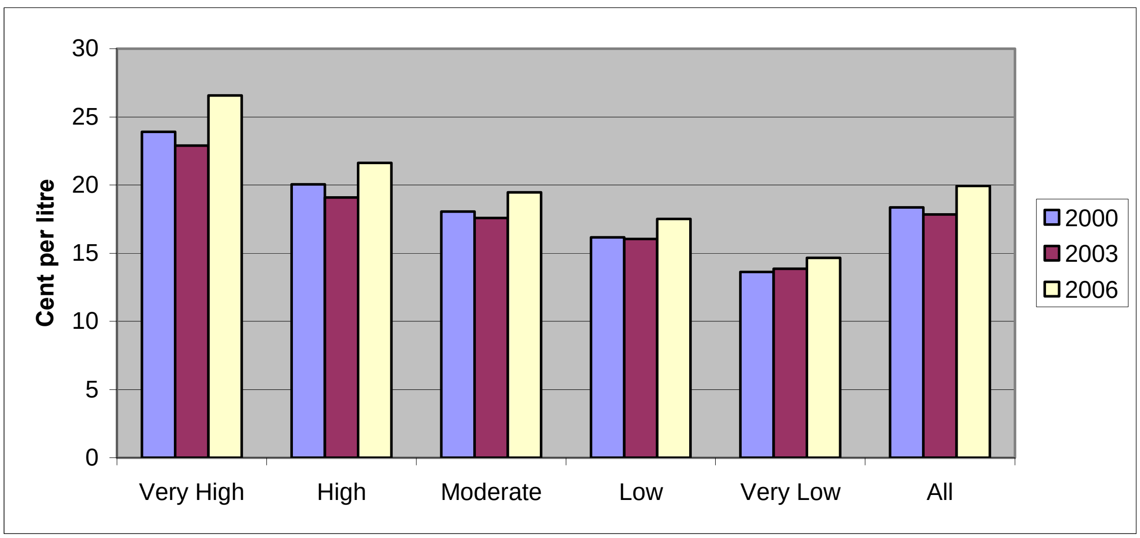
Recent studies of dairy production around the EU have highlighted the cost efficiencies achieved at farm level. For example, Colman and Zhuang (2005) estimated that the English and Welsh dairy farming sector achieved on average a 1.5 percent reduction per annum in total costs of production in the period 1996 to 2003. Pierani and Rizzi (2003) conducted an economic analysis of Italian specialist dairy farms and concluded that cost savings of 3.5 percent per annum were realised in the period 1980 to 1992. Thorne and Fingleton (2006) have shown that Ireland was consistently one of the lowest cost producers of milk in the EU between 1996 and 2004. Further analysis conducted by Fingleton (2004) showed that cost efficiencies were achieved by the Irish dairy farming sector from the late 1990s to the early 2000s but that a large variation in costs between farms continued throughout the time period. Fingleton's analysis shows that the difference in costs of production between the best performing 20 percent of farms and the poorest 20 percent was 11 cent per litre in 2000, which is a cost difference of €27,500 for the average quota size of 250,000 litres. Such a large variation in cost structure is surprising in a small homogenous country like Ireland.

Figure 2.1 presents Irish National Farm Survey data on production costs on specialist milk producers for 2000, 2003 and 2006. The average for the weighted population is presented and the population is also divided into quintiles on the basis of production costs. As is evident from the graph, there is significant variation in production costs

[1] The authors would like to thank the staff of the Teagasc National Farm Survey for the provision of the data.

across farms. The range in costs between the lowest and highest quintiles was 10 cent per litre (cpl) in 2000, and increased to 12 cpl in 2006, thus showing that the variation between producers is increasing. The quintile analysis also reveals the varying degree to which farmers can cope with cost inflation or adverse weather conditions. As can be seen, the very high cost farms increased total production costs by 16 percent from 2003 to 2006 while costs on very low cost farms only increased by 5 percent over the same period.

Figure 2. 1: Mean Total Cost of Production per litre on Specialist Irish Dairy Farms



Source: Irish National Farm Survey

To date relatively little analysis has been conducted in Ireland on the factors affecting cost structures and the reasons for such large variations in costs between farms. The objective of this paper is to draw on research conducted internationally to develop empirical models to explain cost structures in the Irish dairy sector. The paper begins by describing the dataset used; following this the methodology adopted in the paper is outlined, while the final two sections of the paper present and discuss the key findings of the research.

2.2. Data

Irish National Farm Survey data (NFS) from 1998 to 2006 is used to compile and analyse production costs on dairy farms. The NFS is a member of the Farm Accountancy Data Network of Europe and surveys approximately 1200 farms annually. These farms are assigned a weighting factor which enables an aggregation process to represent the full farming population of approximately 115,000 farms. For the purposes of this study only the data collected on dairy farms is used, this is a sample of approximately 340 farms in each year.

The NFS data collection process allocates direct costs of production to specific farm enterprises; see Connolly et al (2006). This facilitates the calculation of direct costs of production per unit of output. However, overhead or fixed costs are not assigned to individual enterprises, this is problematic when the majority of dairy farms in Ireland are mixed enterprise farms. In this paper fixed costs are allocated on the basis of gross output. For the dairy enterprise for example, fixed costs are calculated by estimating the proportion of total farm gross output emanating from the dairy enterprise and allocating an equivalent amount of fixed costs to the dairy enterprise. In the analysis only cash costs are considered. The cost of the farmer's own labour and land are not included in this analysis. Previous studies of cost efficiency have attempted to impute owned labour and land costs, see for example Franks (2001). Due to the heterogeneity of land and labour and the consequent difficulty of sourcing appropriate valuations for both resources, the calculations of costs in this paper includes cash costs only. There are 3083 observations in the dataset, approximately 340 farms each year.

Table 2.1: Summary Statistics for all Specialist Dairy Farms in Ireland

Year	**1998**	**2001**	**2004**	**2006**
Herd Size (Cows)	38	44	45	50
Farm Size (Ha)	38	43	44	47
Farmer's Age (Years)	47	47	49	51
Yield Per Cow (Litres)	4369	4880	4944	5028
Stocking Rate (Cow per Forage Ha)	1.89	1.93	1.91	1.91
Family Farm Income (€'s)	24242	34426	34421	36221

2.3. Methodology

A two step methodological approach is adopted to explore cost structures and to explain the large variation that exists in cost structures in Ireland. First the sector level cost structure is described and following this farm-level cost structures are examined.

The sector level cost structure is described by developing annual cumulative cost curves. A cumulative cost curve provides an indication of the proportion of milk produced nationally at different prices, Colman and Zhuang (2005). Producers are ranked in ascending order of cost per litre of production and the cumulative amount or percentage of milk produced below any particular cost is calculated and plotted. Cumulative cost curves are derived for a number of years allowing us to determine whether total sectoral efficiency is increasing or decreasing. The cost curves can also be compared to those developed in other countries to provide some insight into international competitiveness.

Farm level cost structures are explained by deriving cost functions and through cost mobility analysis. A cost function specifies the efficient use of resources, using the least cost combination of inputs to produce an output. The seminal paper by Burton (1995) developed a cost function for dairy farms in England. Colman and Zhuang (2005) used Burton's specification to compute a cost function for the English and Welsh dairy-farming sector for 1996 and 2003. Their analysis showed that all the explanatory variables were U shaped, meaning that costs of production decreased to a minimum point where economies of scale were achieved and that costs increased thereafter (diseconomies of scale). Their results showed that economies of scale were achieved in herd sizes up to 174 cows.

The ad-hoc average cost function used by Colman and Zhuang (2005) is employed as the average cost function in this research as per equation 3.1.

$AverageCost_t = f($ Herd Size, Herd Size^2, Concentrate Feed per cow, Concentrate per cow^2, Yield per cow, Yield per cow^2, Cow per Ha, Fair soil, Good soil and Farm size)

Equation 3.1

An ordinary least squares regression is implemented to determine which of the independent variables are statistically significant in affecting cost. The coefficients of the regression analysis are also used to plot economies of scale. The average cost function should provide some insight into the factors affecting the variation in farm cost structures.

Individual farmer's cost management is also examined using a cost mobility analysis. The Center for International Studies and Co-operation (CECI) (2006) cites mobility of cost, or farmers' ability to manage their own costs, as a major determinant of farm profitability. Techniques that have previously been applied to income mobility analysis are also appropriate for investigating the stickiness of costs. Phimister et al (2004) used survival analysis to examine the income mobility of Scottish farms. Here a similar methodology is employed to explore cost mobility.

In the analysis farms are disaggregated into cost quintiles, as per Figure 1. Survival and hazard analysis are used to investigate the mobility between quintiles. Using the following procedure, time t is considered as the entry point for a farm into the survey (this may be in different years depending on when the farmer entered the survey), this farm is assigned to a quintile from 1(low costs) to 5 (high costs) in relation to all other farms. If j measures the duration (in years) of a particular farm in a quintile, a survival S_j and hazard h_j function can then be derived.

The survival function measures the probability that the duration in a quintile lasts beyond year j, while the hazard function is the probability that a farm exits out of the quintile, i.e. the probability that the farm improves or disimproves costs relative to all other farms. A Weibull proportional hazard model is then used to test if there is a relationship between farm characteristics and the probability of improvement. To examine the link between farm characteristics and spells in high (low) costs a proportional hazard model is used,

$$h_j(x_i) = h_{j0} \exp(x_i \beta)$$

where h_{j0} is the baseline exit hazard and x_i is the vector of covariates assumed to influence the hazard (Phimister et al. 2004). Using 1998 as the base year, each farm is examined to determine if they improved, regressed or stayed in the same cost quintile from year to year. The farm characteristics associated with cost improvement can then be identified.

2.4. Results

Table 2.2 provides a snapshot of all farms in the period. As shown total production costs have fluctuated over the period; increasing by 6 percent from 1998 to 2002, decreasing by 7 percent from 2002 to 2005 and increasing again by 14 percent from 2005 to 2006. The increase from 2005 to 2006 can be partly explained by an extremely dry summer. Gross output declined over the nine-year sample, with the exception of 2001. Net margin demonstrated an 11 percent nominal decrease in the first eight years, but fell sharply from 10.1 cpl in 2005 to 6.6 cpl in 2006, a 33 percent decrease.

Table 2.2. Average Production Costs, Margins and Output for all specialist dairy farms 1998-2006

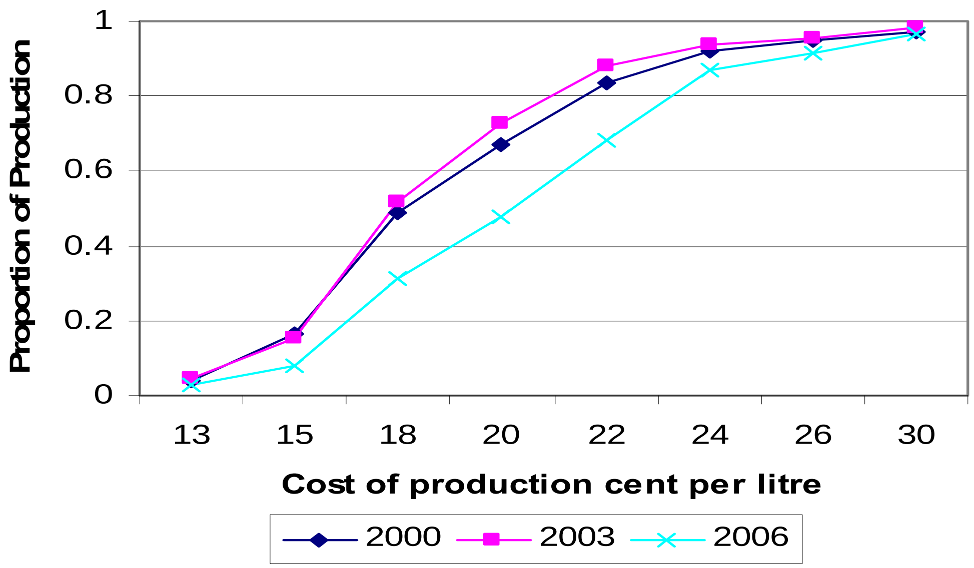
Cent per Litre (Nominal Terms)

	Gross Output	Total Dairy Costs	Dairy Net Margin
1998	0.296	0.182	0.114
1999	0.279	0.180	0.099
2000	0.299	0.185	0.114
2001	0.313	0.183	0.130
2002	0.295	0.195	0.101
2003	0.287	0.181	0.106
2004	0.301	0.186	0.115
2005	0.282	0.180	0.102
2006	0.272	0.206	0.066

Source: National Farm Survey Data

The sector level cumulative cost curve of milk production for 2000, 2003 and 2006 are presented in Figure 2. As can be seen some efficiency gains were made from 2000 to 2003, as the cumulative cost curve for 2003 is further to the left. In both 2000 and 2003 over 50 percent of all milk was produced at 18 cent per litre or less. In 2006 however, only 30 percent of milk was produced at 18 cent per litre or less, indicating efficiency losses.

Figure 2.2. Cumulative Cost Curve for Irish Dairy Sector



The cumulative cost curves allow us to measure the cost efficiency of the sector as a whole; however they provide little information about individual farm cost efficiency. To explore costs structures at the farm level, cost functions were estimated. Table 2.3 presents the results of the average cost function regressions on the 2003 and 2006 data. The coefficients show the relationship between the independent variable and per unit cost. A negative coefficient suggests that costs decrease as this variable increases and the opposite is the case for those with a positive sign.

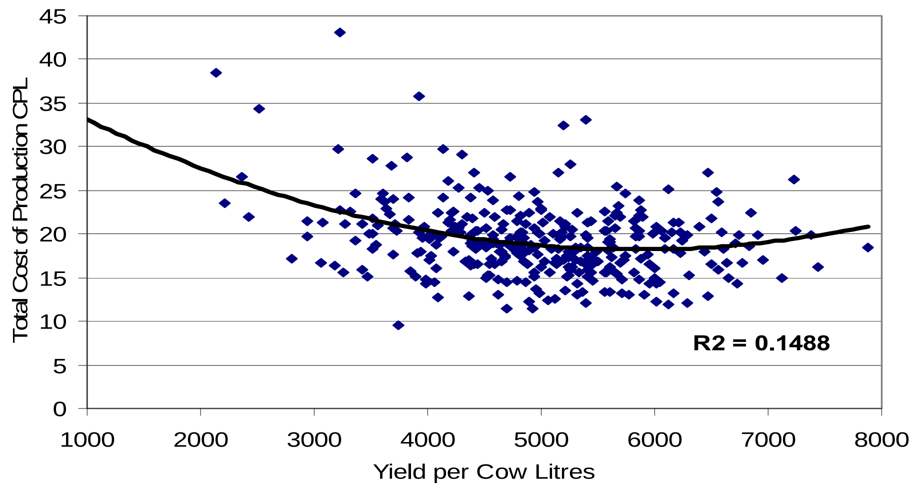
Table 2.3. Average Cost Function Results 2003 and 2006

	2003		2006	
	Coefficient	T value	Coefficient	T value
Constant	0.4064416	13.19	.2952356	10.18
Cows	2.40E-06	-0.81	-.0006823	-2.31
Cows²	3.43E-06	1.83	3.43e-06	3.16
Yield per cow	-0.0000949	-8.12	-.0000436	-4.36
Yield per cow2	7.82E-09	6.66	2.98e-09	3.11
Fair soil	-0.0046274	-1.17	-.0000271	-0.01
Poor soil	-0.006079	-1.58	.0023193	0.51
Cow per Ha	0.0026248	0.7	-.0307578	-3.91
Farm size	0.0000754	0.68	.0001888	1.10
Concentrates per Cow	0.0031692	6.93	.0038101	6.19
Concentrates per cow2	-0.0000172	-2.33	-.0000281	-2.74

The results for the regression on the 2006 data are as expected; most of the variables are statistically significant, with the exception of farm size and soil quality, and all of the significant variables demonstrate the expected signs. For example, the effect of herd size is negative while herd size squared is positive. This suggests that costs of production decrease as herd size increases but only up to a certain point, i.e. the relationship is non-linear. In other words, economies of scale are present. It is somewhat surprising that the results for 2003 suggest that herd size is not significant.

Yield per cow is significant in both years and is negative and non-linear. This suggests that costs of production decrease as yield per cow increases but only up to a certain point and decrease thereafter. It is possible that the costs, in terms stocking rate and purchased feed, of pushing yields per cow beyond a certain limit are greater than the benefits achieved in the additional supply per cow. The effect of the yield variable is also likely to be interlinked with the stocking rate and purchased feed variables. Figure 2.3 presents the relationship between yield and production costs graphically. The graph shows the optimal yield per cow to be somewhere around 6,000 litres per cow.

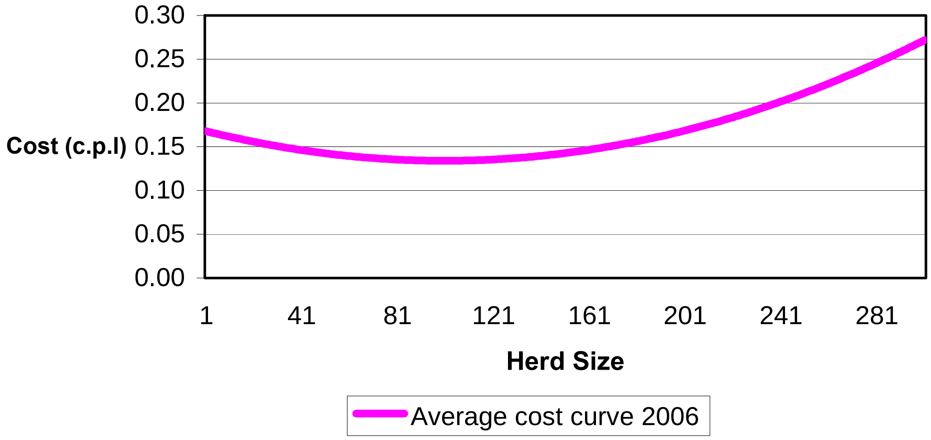
Figure 2.3 : The Relationship between Production Costs and Yield per Cow 2006



Soil quality and farm size have no significant effect on average cost in either 2003 or 2006. Farm size is a measure of total land area and as such there may be multicollinearity problems between herd size and stocking density, thus making this variable not significant. The non-significance of soil quality may be explained by the relatively little variability in this variable, as the vast majority of farms are on good soils.

The average cost curve (ACC) for the dairy sector in 2006 was subsequently plotted from the results of the average cost function. The 2003 data was not plotted due to the non significance of many of the variables. Calculating the ACC involves plotting equation 1 by using the coefficients obtained from the regression and multiplying them by their respective average from the sample. The average cost curve is presented in Figure 3.4. The results show that economies of scale exist up to about 99 cows and diseconomies of scale set in thereafter. Interestingly costs increase dramatically faster as size increases over 160 cows. Labour costs become an issue as the dairy farms expand and this could explain this rise in cost. Given the constraints of milk quota, obtaining an optimal herd of 99 cows remains a challenge; the average herd size in Ireland was 55 cows in 2006.

Figure 2.4. Average Cost Curve 2006



Comparing the Irish average cost curve with that produced by Colman and Zhuang (2005), the optimum herd size in 2003 in England and Wales was 174 cows. The slope of Colman and Zhuang's average reduces much faster as herd size increases up to the optimum point. This implies that farms in England and Wales are attaining economies of scale quicker than Ireland as herd size increases.

2.4.1 Survival and Hazard Model and Cost Mobility

A panel of farmers who remained in the sample for the nine-year period was compiled for a transition matrix, totalling 114 sample farms. All farms in the sample were used in the survival analysis not only those that stayed in the sample for all nine years. A cost quintile analysis was conducted and a transition matrix derived to measure the movement of farms between cost quintiles from 1998 to 2006. The results in Table 3.4 show that over 40 percent of those in the lowest total cost quintile in 1998 are still in lowest cost quintile in 2006, while inversely for those who had the highest costs in 1998 over half of them were still in that quintile in 2006. Only 7 percent of those in the high cost quintile in 1998 were in the low cost quintile in 2006. This suggests that there is limited mobility in cost structure and the majority of the movement that occurs is to the closest quintile.

Table 2.4: Transition matrix of cost mobility for 1998 and 2006 quintiles

		1998 Quintiles					
		1	2	3	4	5	Total
2006 Quintiles	1	41%	30%	11%	11%	7%	100%
	2	48%	26%	13%	9%	4%	100%
	3	22%	17%	39%	13%	9%	100%
	4	12%	16%	32%	28%	12%	100%
	5	0%	13%	23%	17%	47%	100%

Survival analysis is used to calculate the probability that a farm can move through the cost quintiles. Table 2.5 illustrates the results of the survival analysis for the sample. It shows the probability of farms improving their cost structure.

Table 2.5. Survival Analysis 1998-2006

Year	**Probability of Improvement**
1998	0.2390
1999	0.2814
2000	0.2580
2001	0.2871
2002	0.2805
2003	0.2816
2004	0.3438
2005	0.2547
2006	0.2736

The results show that the probability of improving cost structure has increased marginally over the period. While this information is useful, the hazard model can be used to identify the characteristics of those farms that are improving cost structure. The following results were attained from the Weilbull proportional model.

Table 2.6. Results of Weilbull Proportional Hazard Model

	Hazard	**T-stat**
Herd Size	.9966749	-1.99
Farm Size	1.003988	2.42
Cow per Ha	1.049021	0.80
Concentrates	.9858114	-3.72
Yield per Cow	.9999817	-0.53
Good Soil	1.125795	1.83
Fair Soil	1.285962	3.47

The hazard ratios identify the factors significantly affecting a farmer's probability of improving cost structure. Those with fair soil and good soil are 28 percent and 12 percent respectively more likely than those with poor soil to improve cost structure. This result suggest that farming on poor soil, although the number of dairy farms in this category are quite low, is a significant disadvantage and limits the farmer's ability to improve costs. Increasing farm size also improves the probability that a farm will improve cost structure, while the effect of stocking rate and yield per cow are not statistically significant. Increasing herd size and concentrates will decrease the probability of improving cost structure by approximately 1 percent.

2.5. Conclusions

The purpose of this paper is to analysis the cost efficiency of Irish dairy farms with a view to explaining why such large differences exist in cost structure. Various methodologies were employed to determine the factors driving costs as well as the characteristics of those farms that succeeded in maintaining low costs. Employing an average cost function like Colman and Zhuang (2005), it was determined from 2006 data that the optimal herd size was 99 cows, compared to the current average of 55 thus there is ample capacity to exploit economies of scale. While economies of scale may be exploited, the presence of the milk quota regime continues to act as a major barrier to expansion. The results suggest that if milk quotas were removed or enlarged, as is likely over the next few years, Ireland would be well placed to increase production while maintaining cost efficiency. Increasing yield per cow and stocking rate also decrease costs implying that scale and improving efficiency is key to reducing cost.

While significant variation in costs exist across farms, the cost mobility analysis showed that, relative to their peers, individual farmer's cost efficiency changed very little over the period. Using a cost quintile analysis and a transition matrix, the results showed that the majority farmers stay in the same cost quintile or only move to the nearest quintile. This suggests that high cost farmers tend to remain high cost. A hazard model was used to identify the characteristics of farmers that improve their cost efficiency over time. The results yielded limited information on the drivers of cost efficiency, with farm size and soil type being the main drivers of change. The analysis revealed that physical endowments like soil type have a significant negative impact on the probability on improving cost structure, suggesting that even increased scale and technical efficiency cannot compensate for this disadvantage.

CHAPTER 3

MILK QUOTA TRADE MECHANISMS

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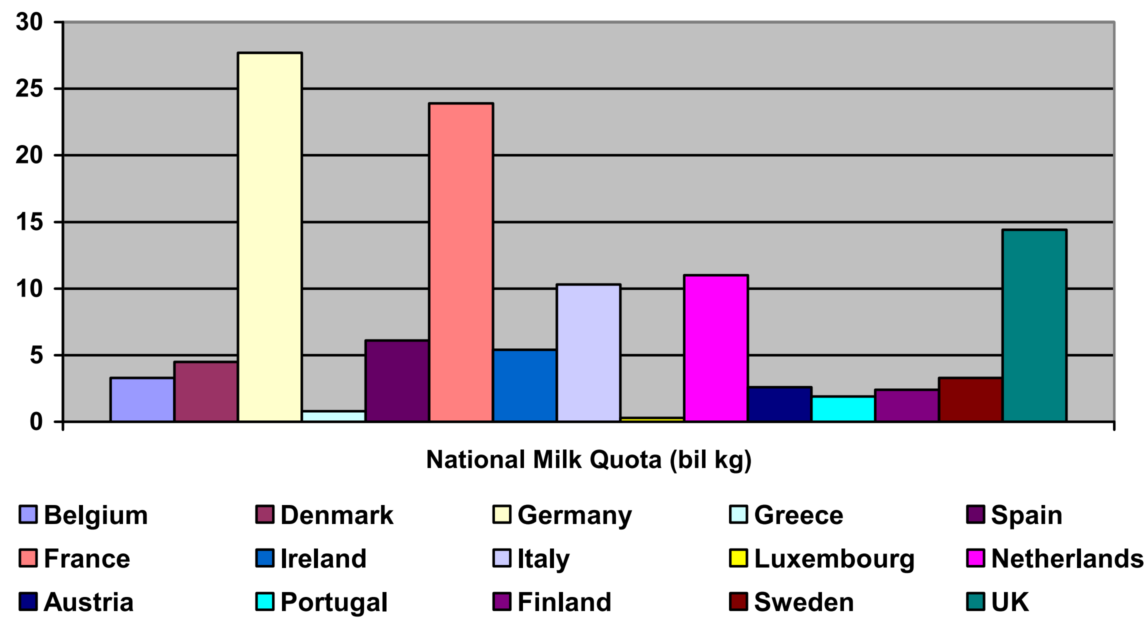
3.1. Introduction

Milk quota system was first introduced in the EU dairy sector in 1984 in bid to curb milk over-production and hence to put a cap on spending of EU budget on dairy subsidies. Under the milk quota system, each member state was allocated a quota limit based on their historical annual milk production level. This allocated national quota covers total milk production in a quota year, starting on 1 April and ending on 31 March. The quota levels for the EU-15 states for the year 2005/06 are shown in Figure 3.1. European countries which entered the EU afterwards were allocated with milk quota based on their respective historical annual production levels.

Figure 3.1. Milk quota levels for the EU-15 member states (20005/06)



Source: EU Commission, 2006

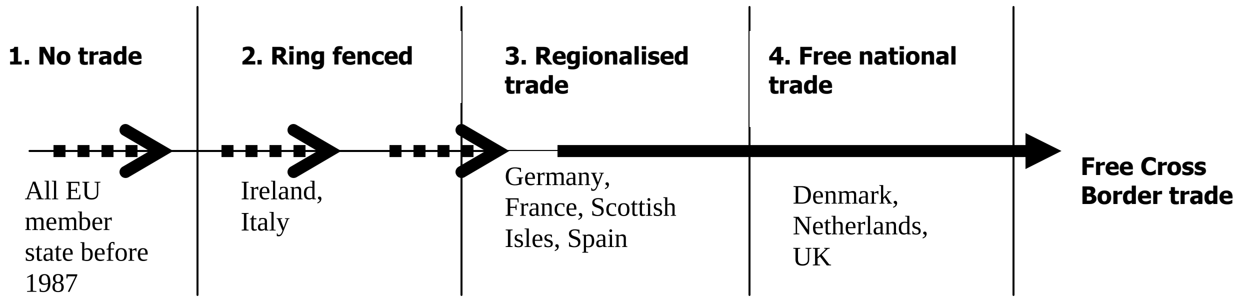
Under the quota system, each member state is allowed to produce milk within its allocated quota level in a given quota year. A super levy, 115% of the EU target price for milk for that year, was implemented for the states that exceed the allocated quota and was payable on the over produced quantity. The country paying super levy imposes it on producers, who have exceeded their respective individual quota (which are also based on historical production levels). During the early years of quota introduction, quota trade was not allowed within a member state hence farmers had to produce within their quota limit or pay super levy. This restricted farmers' options on deciding to exit or expand milk production such that, on one hand, removed an opportunity from non-profit making farms to sell quota and exit farming, while on the other hand, the efficient farmers were not allowed with an opportunity to expand their production level by buying milk quota. This was however, changed in 1986/87 when the member states were allowed to trade milk quota trade within the state. It aimed to increase efficiency in milk production as efficient milk producers can now acquire additional quota level by purchasing or leasing quota from less efficient farmers and hence increase production without having to pay a super levy. There are a number of quota trade systems within different EU member states which are described in the following.

3.2. Quota trades in the EU states

At the time when quota trade was introduced, member states were allowed to adopt trade mechanisms that suit them better which resulted in different types of trade mechanism in different EU states. The quota trades in different member states differs from each other as some states introduced obligatory attachment of land (France, Spain) and some not (Germany, Ireland); some regulated quota trade by a central administration (Ireland, Denmark) while others allowed trade at regional auctioneers (UK, Germany). However, the major difference between quota trades in the member states was the restrictions implemented on area of trade. There was a wide range of area of trade in different member states. Based on the area of trade restrictions, quota trades in the EU can be categorized into four different levels (Figure 3.2). The first category is when no quota trade is allowed. It happened in all EU states from 1984 to

1987 when farmers were not allowed to sell or buy milk quota. However, since 1987 when quota trade was allowed, member states had adopted the rest of three categories.

Figure 3.2. Quota trade mechanisms in the EU



3.2.1. Ring fenced to milk processors

This form of quota trade is based on the fact that all dairy farmers have a contract with a local milk processor. The milk quota trade in this mechanism is restricted around those milk processors. In this case, a farmer can trade milk quota with a farmer with same milk processor. That means milk production cannot go out of a particular processor. Ireland operates milk trade under this mechanism. Italy is another state which uses this mechanism however, there is a relaxation in the mechanism where farmers from other processor (co-operatives) can purchase quota if it is still available after 30 days period.

Ireland

Milk quota trade in Ireland started as early as 1987 through leasing and selling of milk quota. The quota transfer was ring fenced within co-operatives and quota price were set by the Department of Food and Agriculture. Since the start of 2007, a new quota exchange programme has been introduced where quota trading is still ring fenced to cooperatives but quota price is based on farmers' bids. Under the new exchange system, on the sale side, farmers can offer as much quota as they like with a restriction of 30% of total quantity offered for sale is transferred to a priority pool. Farmers in the priority category (young farmers, new entrants, successors etc) can bid for this priority pool at a maximum price of 12 cpl. This price is set by the DAF. On the demand side, a farmer is allowed to bid for a maximum of 60,000 l of quota. An initial equilibrium price was calculated once all bids were finalised. All purchase bids that exceed 40% of this initial equilibrium price were then removed and second equilibrium price which is the market clearing price was calculated. This is done for each co-operative participating in the quota transfer hence each co-operative will have its own market clearing price. The transfer of quota within each co-operative would then take place at this market clearing price.

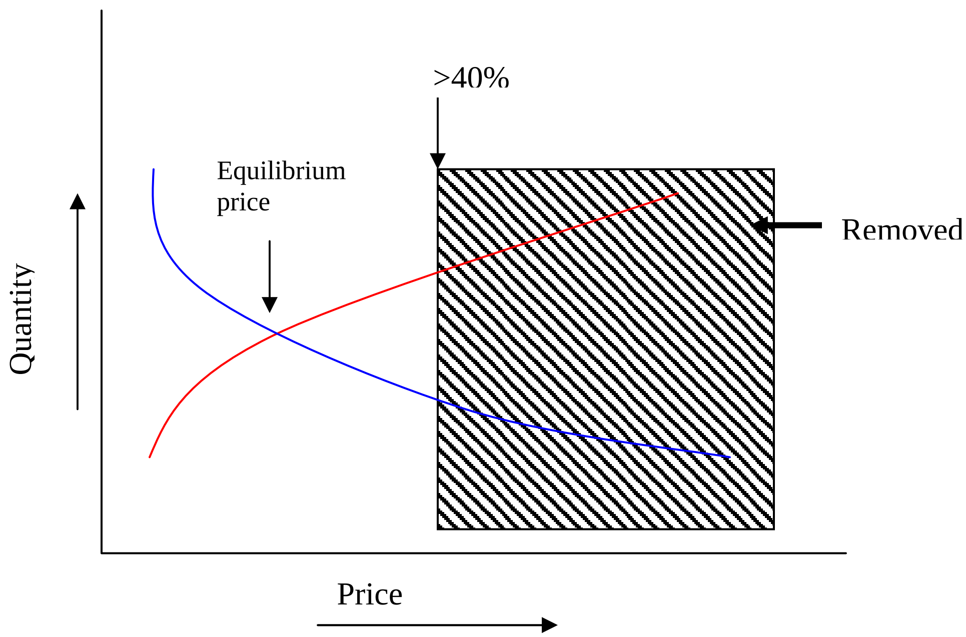
3.2.2. Regionalised quota trade

The trade is restricted at a regional base in this type of mechanism. The EU states like Germany and France adopted this mechanism for milk quota trade in the country. This mechanism is more flexible than ring fence mechanism as farmers can trade between co-operatives within a region and have more options to place their bids. The mechanism in Germany is described below.

Germany

Quota trade in Germany started in 1990/91 when farmers were allowed to lease in milk quota. Milk quota transfer was linked with land transfer at that time which was changed in following year when quota can be leased out without land. Since 2000, milk quota transfer is based on a regionalised auction system. The milk transfer is restricted to 21 trading zones based on NUTS I and II levels. This transfer takes place three times a year. The buyers bidding at the suction should be active dairy producers and have to pay a fee to participate in the auction. A small part of the transferred milk quotas are transferred to the national reserve which can be reallocated to the young/hardship programmes. The milk quota price is calculated for each regional auction and depends on bided quantity and the respective equilibrium price. The equilibrium price is calculated in several steps. First, each quantity offered and the referring price are listed, starting with the lowest price. Second, all demands with reference quantity and price are listed, starting with the highest price. Third, the sum, starting with the offered quantity with the highest price and the demanded quantity with the lowest price, is built up. Subsequently, the price with the lowest difference between offered and demanded quantity is established. Then, the offers with a 40 % higher price than the calculated price are removed to calculate a new equilibrium price (Figure 3.3). This scheme will not be used if the first price calculation leads to a price below 30 ct/kg quota. The equilibrium price must now satisfy the condition that the demanded quantities to be transferred are at least equal to the offered quantities. If this is not the case, the price is corrected downwards stepwise (in one cent increments per kg).

Figure 3.3. Supply and demand curve in a German auction



Source: Heuttal et al., 2006

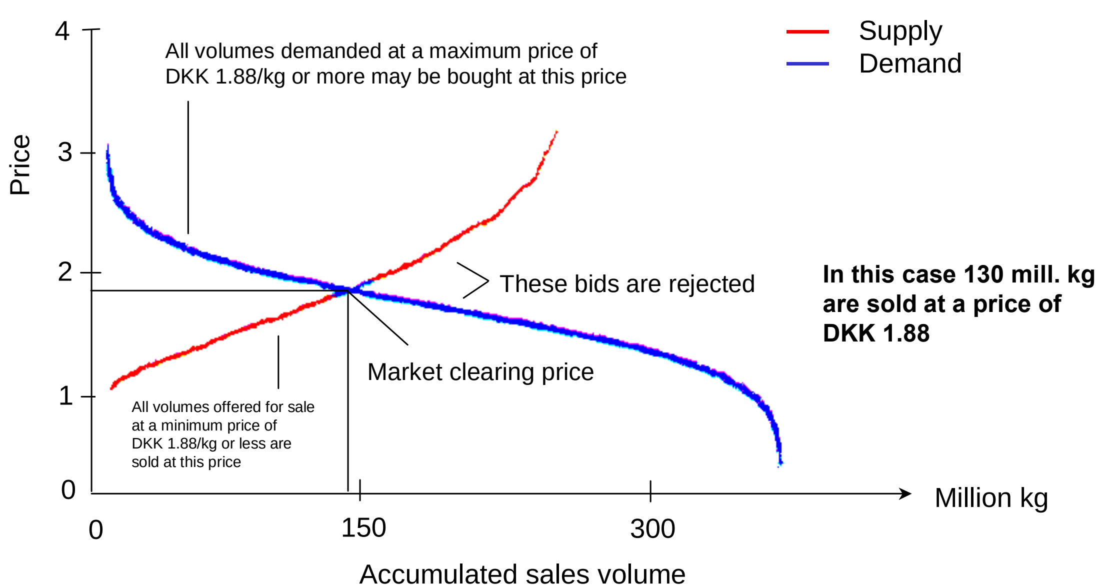
3.2.3. National quota trade

There is no spatial restriction within a state in this type of transfer mechanism. Farmers can bid to sell and buy milk quota from farms any where in the country. This mechanism is most flexible where milk quota is not restricted to any area. It may lead to a high concentration of milk production in the most profitable area of the country. The EU states such as Denmark, the UK and the Netherlands adopted this mechanism. A brief description of quota trade in Denmark is provided below.

Denmark

Denmark started a milk quota exchange programme in 1997. The Danish Milk Board administers and registers all kinds of allocation and transfer of quota. The Milk Board runs 4 quota exchanges a year. Quota is transferred to the purchaser within two months of trade. As of the November 2001 exchange a 1% deduction scheme was introduced, implying that 1% is deducted from sold quota and transferred to the 'free quantities', to be used for allocation of free quantities to new establishments (50% given free of costs). All producers are entitled to place one bid for purchase or sale of quota at the exchange. Any producer, wanting to sell quota, makes an offer to sell stating quantity and minimum price and any producer, wanting to buy quota, makes an offer, stating quantity and maximum price.

Figure 3.4. supply and demand curves in Danish Milk quota exchange



source: Danish Milk Board

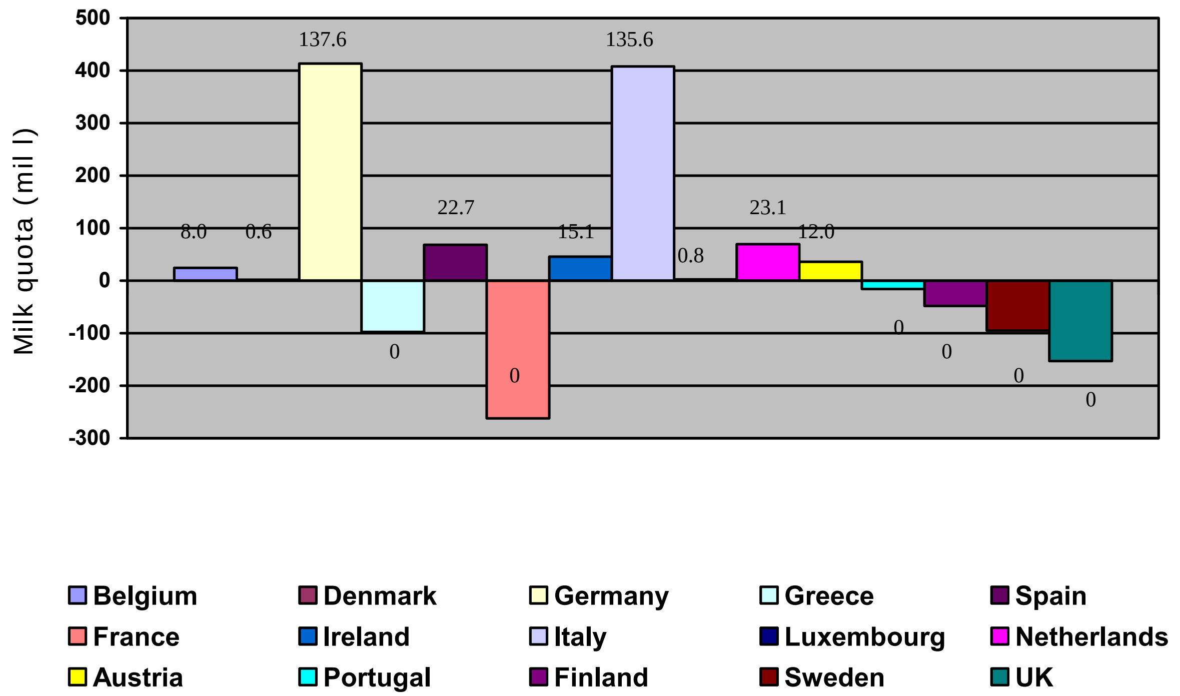
There is no restriction on quantity to purchase so a producer may bid to purchase as much quota as he requires. All individual bids are adjusted to an average fat content of 4.36% to arrive at a market clearing price of the quota exchange. All bids are recorded in a supply and a demand curve and an equilibrium price or the market clearing price is determined at the cut-off point between the two curves (Figure 3.4). Producers, who would sell at a price lower or equal to the market clearing price, will sell. And producers, who would buy at a price higher or equal to the market clearing price, will buy. Remaining offers are rejected. Producers, who have been rejected on account of either a too low purchase bid or a too high sales bid, will have to try again at the following quota exchange.

3.2.4. A cross border quota trade

A fourth category of quota trade can be perceived as a cross border trade. This category does not exist at the moment but can be assumed as a possible measure to be implemented in preparation of quota removal in the EU by 2015. When the quota trade was introduced within a member states, it aimed at increasing production efficiency of dairy farms. This trade under went further changes within several member states to increase production efficiency. For instance, quota trade in the UK started as a ring fenced trade but quota is allowed to trade nationally since 1994 (NDC, 1996). If we look at the trend of milk quota transfer in the EU states, coupled by recent reforms of the CAP, a movement towards a free quota trade can be established as shown in Figure 3.2. Although, quota trade within a state allows quota production balance within a country and increases production efficiency but an imbalance of milk production between the member states still exists. Some member states continuously produced milk below national quota limit whereas other kept on over producing and pay super levy.

The figures of over production and under production in some of the member states and super levy paid by the over producing states for year 2004/5 are shown in Figure 3.5. The over-production countries such as Germany and Italy had around 400 milk l of over production and paid around € 136 mil on super levy while many countries such as France and the UK did not use all of their national quota level. A cross border quota trade would effectively reduce this imbalance in production between member states. Hence we presumed that the last category of quota trade will be a cross border trade. This is a proposed trade mechanism where farmers from different member states can sell or buy quota to one another. This trade will help in balancing production in different member states as the under producing states would be able to sell their quota to over producing states.

Figure 3.5. Milk production in excess or deficit in 2004/05 in the EU-15 states
[Figures on top of each bar is the levy paid in 2005 in € million]**.**



Source: Danish Milk Board, 2004

3.3. Discussion and Conclusions

Milk quota trade in the EU states ranges from a very restrictive ring-fence system to a free national system. Ring fencing is especially a good mechanism to restrict milk production in a desired area. This mechanism allows a more uniform distribution of milk production in a country. However, farmers bidding to sale or expand production have a limited market to do so and efficient producers are restricted over the amount of available quota if they wish to increase their production. Hence this mechanism favours 'equity' among dairy farmers but fails to promote 'efficiency' in milk production. The regional milk trade mechanism has a wider market than ring fence mechanism but is still restrictive to certain regions. It provides opportunity to efficient farmers to expand within regional quota availability. Although milk production at the farm level might change, this mechanism still keeps total milk production constant within a regional. The free national market provides a wider opportunity for a farmer for selling or buying milk quota. Farmers in the countries implementing this mechanism have access to the national quota market and hence can make decision more effectively to expand or exist dairy farming. This mechanism tends to move milk quota towards efficient regions and create a specialized milk producing regions within a country. For instance, since the Netherlands opted for a national trade mechanism, a movement of quota from south to north-east regions created a specialized milk producing area especially around Gelderland (Bailey, 2002).

The last mechanism ie., the cross border trade is as stated earlier, one of the possible routes envisaged by the EU for the 'soft landing' of milk quota abolition. This would allow the member states who are producing milk over quota limit to buy quota from under-producing members'. In another words milk quota would not remain limiting for those high producing states and the impact of milk quota abolishment would not be large compared to when quota is limiting.

In Ireland, milk quota transfer is still carried out to date within ring fenced areas. It has been successful in keeping milk production spread over the country. The geographical distribution of milk production in the country suggests that large efficient dairy farms are concentrated to the southern part while small dairy farms are more prominent in the north-western part of the country (Hennessy and Shrestha, 2007). The national quota exchanges showed that there is more demand for milk from the south part of the country. The country may move to regional or national quota trade mechanism which would allow these efficient farms to produce more milk. However, the downside of that move would be the loss of small farms in the north-western part. Studies showed that although the farms are smaller in these regions, the dependability of agriculture is higher there compared to other regions (Hennessy et al., 2007). Hence, any move to change quota trade in Ireland should be made cautiously.

CHAPTER 4

ESTIMATING QUOTA VALUE AND THE INEFFICIENCIES OF RESTRICTED QUOTA TRADE

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4.1. Introduction

Dairy production in the EU is constrained by production quotas. Milk quota transfers between farmers have been allowed since the early 1980s, although to varying degrees in different Member States. In some Member States quota is traded freely in an auction system, while in others trade is regionalised or "ring-fenced", for example Ireland, Germany, parts of Scotland and France. The motivations behind the ring-fencing of milk quota mostly relate to social, rural development and local policy goals. While ring-fencing may be successful in meeting these objectives, it has implications for the efficiency of the milk producing sector as a whole.

This paper aims to quantify the efficiency implications of regionalising quota trade. A simulation model of quota trade is developed using farm data for Ireland. The model is employed to estimate the optimal allocation of milk quota in a perfectly functioning quota trade market where quota can be traded nationally and subsequently in a scenario where the trade of quota is ring-fenced. The novel component of this research is that national aggregation factors facilitate the derivation of cumulative cost curves of production for the Irish dairy farm sector as a whole, thereby enabling a comparison of sector-wide efficiency under the two forms of quota trade.

The paper also attempts to quantify the inefficiencies arising from policy uncertainty in relation to the future of the EU milk quota regime. The model is simulated for a number of milk quota reform scenarios and the implications of an early abolition of the EU milk quota for quota trade prices are quantified and the consequent effects of this inefficiency are discussed. While the data used in this paper are specific to Ireland, the methodology developed is sufficiently general to be applied to other FADN datasets to estimate the inefficiencies of regionalised quota trade. Using the EU wide FADN dataset the methodology could also be used to estimate the potential efficiency gains that could be achieved if milk quotas in the EU were permitted to trade across international borders.

4.2. Background

There has been much written on the effect of the EU milk quota system on efficiency and the impact on assets values; see for example Harvey (1983), Burrell (1987) and Dawson (1991). These papers, and many others, tend to support the general theory put forward by Alston (1981) and Oskam et al (1992); that the imposition of a quota generates an economic inefficiency in the sector but that the more freely traded quotas are, the smaller that inefficiency. The reasoning being that if quotas are tradable, more efficient farmers will purchase quota from the less efficient and the national quota will be produced at a lower cost.

A number of empirical studies have attempted to quantify the relationship between quota trade and sector efficiency. Boots et al (1996) used a simulation model to quantify the short-term effects of quota trade distortion for a panel of specialist Dutch dairy farms. They concluded that liberal quota trade increases farm profit and leads to a geographical concentration of production. They did not however, draw any conclusions about sector-wide efficiency. In a number of studies on UK dairy farming, Colman (2000) and Colman et al (2002) developed models to estimate the optimal allocation of milk quota in the UK. The results showed that substantially more redistribution of quota was required for the UK dairy farm structure to reach its optimal position. Another relevant study is that of Alvarez et al (2006). They estimated quota values for a sample of Spanish dairy farms and then decomposed those values according to efficiency, size and input price effects. Their results revealed that efficiency was the most important factor in explaining the variation in quota values. They concluded that given the difficulty in observing farm efficiency, any government intervention in quota markets is likely to be misguided and therefore the more liberal the trade of quota the more efficient the outcome.

Regionalised quota trade has been in operation in Ireland since January 2007 under an exchange system where farmers can bid to purchase or sell quota at their desired price. Quota is then traded at the market equilibrium price, albeit with some intervention and market cooling mechanisms.[2] In 2007, purchasers were allowed a maximum allocation of 80,000 litres per exchange. Each dairy processor operates an exchange and quotas are ring-fenced so that they can not be moved from one exchange to another. This ring-fencing mechanism, therefore, ensures security of supply for dairy processors it does also however, afford the processors considerable market power.[3] There are over 20 separate exchanges, with prices in the second 2007 exchange varying from 12 cent to 45 cent per litre. In this paper the economic implications of this quota trade system are explored.

While a number of studies have addressed the inefficiencies of quota trade, relatively few have explored the inefficiencies of policy uncertainty and the implications for sectoral efficiency. Colman (2000) discusses this issue. He highlights how decisions taken by some dairy farmers in the early years of the quota regime, on the basis of a finite expected life, subsequently turned out to be sub-optimal when the life of the quota was extended. The opposite problem, however, is likely to be the case in the coming years. The 2003 Mid Term Review of the CAP extended the life of the milk quota regime to 2015. However, the CAP Health Check in 2008 has suggested that quotas may be abolished earlier than that date or may be phased out before that date by a process of gradual quota expansion. If quotas become ineffective before 2015, it is likely that farmers will have over paid for quota in the belief that it would remain binding until

[2] Full information on the milk quota exchange scheme is available from www.agriculture.gov.ie.

[3] In theory allowing processors control over the allocation of quota may give them the opportunity to manipulate the prices paid to farmers without the risk of losing supply. In reality however, all of these processors are operated by a co-operative board comprising farmer members and there is very little difference in the milk prices paid across processors.

2015, resulting in further efficiency losses for the sector. This paper attempts to quantify the cost of this policy uncertainty.

The ensuing section of the paper presents the theoretical model underlying the empirical analysis following this, the specification of the empirical model is outlined and then results of the analysis are presented.

4.3. Theoretical Model

Employing a discrete time specification, the objective function of an individual farmer, denoted by subscript *i*, is expressed as:

$$\underset{Q_{it}}{Max}\ \Pi_i = \sum_{t=0}^{T} \frac{1}{\left(1+r_i\right)^t}\left[\pi(M_{it}) - P_t.Q_{it} - C(Q_{it})\right] \qquad (1)$$

Here the farmer chooses a quantity Q_{it} of quota to purchase in each period (year) that maximises a discounted stream of annual cashflows between the current period $t=0$ and the period when quota is abolished, $t=T$. The first component in the square brackets represents the farm's cash margin from milk deliveries according to its milk quota (M_{it}) in period *t*[4]. The second component ($P_t.Q_{it}$) is the investment in quota the farmer makes in period *t* which is simply the price of quota in that period (P_t) times the quantity of quota purchased (Q_{it}). The final component in equation (1) represents adjustment costs to the farmer associated with expansion of milk production by amount Q_{it}. Adjustment costs include for example, additional housing, land, labour, etc, these are explained in detail in the next section. It should be noted that in a regionalised quota market the variables in equation 1 will also have a region subscript.

Since it is assumed that milk deliveries M_{it} are exactly equal to the farm's milk quota in period *t*, then:

$$M_{it} = M_{it-1} + Q_{it} \qquad (2)$$

---

[4] To avoid notational clutter the profit function displays only milk quota (*M_{it}*) in its argument. It also comprises a vector of other factor inputs as well as cost and revenue coefficients.

Thus milk deliveries in period *t* are equal to milk deliveries in period $t-1$ plus quota purchased in period *t*. Equation (2) therefore defines the quota constraint that limits the farmer's optimisation problem. The Lagrangian for farm *i*'s maximisation problem is:

$$L_i = \sum_{t=0}^{T} \frac{1}{(1+r_i)^t} \left[\pi(M_{it}) - P_t.Q_{it} - C(Q_{it}) \right] + \sum_{t=0}^{T} \lambda_{it} \left(M_{it-1} + Q_{it} - M_{it} \right) \qquad (3)$$

Here λ_{it} is the Lagrange multiplier associated with the constraint that relates M_{it} to M_{it-1}. It represents the marginal value to farmer *i* from relaxing the milk production constraint by one unit. This is simply the shadow price of milk quota and it specifies the marginal effect of an increase in M_{it} on the value of the farm's discounted cash flows between $t=0$ and $t=T$ discounted to time 0.

To simplify the algebra define:

$$\phi_{it} = (1+r_i)^t \lambda_{it} \qquad (4)$$

Here ϕ_t is the value to the farmer of an additional unit of quota at time *t* and in time *t* (i.e. undiscounted) values.

The Lagrangian can now be rewritten as:

$$L_i = \sum_{t=0}^{T} \frac{1}{(1+r_i)^t} \left[\pi(M_{it}) - P_t Q_{it} - C(Q_{it}) + \phi_t \left(M_{it-1} + Q_{it} - M_{it} \right) \right] \qquad (5)$$

The first order condition for the farm's investment in milk quota in period *t* is therefore:

$$\frac{\partial L}{\partial Q_{it}}: \quad \frac{1}{(1+r_i)^t} \left[-P_t - C'(Q_{it}) + \phi_{it} \right] = 0 \qquad (6)$$

which is equivalent to:

$$P_t + C'(Q_{it}) = \phi_{it} \qquad (7)$$

The left hand side of this expression is the price of milk quota plus the marginal adjustment cost. Therefore, equation (7) states that the farm invests in milk quota until the point where the cost of acquiring (and utilising) additional milk quota equals the marginal value product (shadow price) of the quota.

Next consider the first order condition for the farm's milk quota constraint (M_{it}) in period *t*. The first order condition for M_{it} is::

$$\frac{\partial L}{\partial M_{it}}: \quad \frac{1}{(1+r_i)^t}[\pi'(M_{it})-\phi_{it}]+\frac{1}{(1+r_i)^{t+1}}\phi_{it+1}=0 \tag{8}$$

Multiplying by $(1+r_i)^{t+1}$ and rearranging yields

$$(1+r_i)\pi'(M_{it})=(1+r_i)\phi_{it}-\phi_{it+1} \tag{9}$$

Defining $\Delta\phi_{it}=\phi_{it+1}-\phi_{it}$ equation (9) can be written as:

$$\pi'(M_{it})=\frac{1}{1+r_i}(r_i\phi_{it}-\Delta\phi_{it}) \tag{10}$$

In this equation the left hand side is the marginal revenue product of milk quota while the right hand side is the opportunity cost of a unit of milk quota. Owning a unit of milk quota for a time period requires forgoing $r_i\phi_{it}$ of real interest since the discount rate r_i represents farm *i*'s opportunity cost of capital. In addition, there are offsetting capital value losses $\Delta\phi_{it}$ as the price of quota falls as time approaches the period when quota is abolished.

This paper employs an empirical specification of the constrained optimisation problem defined by equations (1) and (2). Using estimates of farm level adjustment costs and projected milk prices, estimates of the marginal revenue product (economic value) of milk quota, $\pi'(M_{it})$, are derived for a sample of dairy farms for the period up to 2015. In turn, using equation (7) the analysis estimates optimal volumes (Q_{it}) of quota that individual farms are projected to demand (or supply) at alternative levels of milk quota price. Aggregation of these results enables the empirical estimation of demand and supply schedules for milk quota.

4.4. Empirical Strategy

The theoretical model is made operational with a farm-level optimisation model. It is assumed that farmers behave to maximise profit subject to physical, financial and policy related constraints. The model is a multi-period optimisation model solving in EXCEL. It is assumed that milk quotas remain binding until 2015 and the time horizon of the optimisation problem specified in equation 1 covers a 9 year period between 2007 ($t = 0$) and 2015 ($t = T$). When the model is optimised the economic (shadow) value of an additional unit of quota is estimated. To simplify the empirical analysis we assume that farms that invest in quota only do so in the first time period (*t = 0*). Thus we can drop the *t* subscript from the Q_{it}. Under the milk quota exchange system in operation in Ireland purchases, in any given period, are limited to 80,000 litres per farm, hence $Q_i \leq$ 80,000.

The economic value of quota is estimated as the sum of the discounted stream of annual cashflows between the current period $t = 0$ and the period when quota is abolished, $t = T$. Data on gross output and costs are taken from the 2006 NFS for each farmer $i = 1..n$ and projected for each year *t* using FAPRI-Ireland projections (Binfield et al 2007). All technical coefficients, as recorded by the NFS, are assumed to remain static over the period. Profit from milk production $\left[\pi(M_{it})\right]$ is equal to gross output less variable and overhead costs. The discounted sum of future cashflows relating to owned quota are used to estimate the price at which farmers would be willing to sell quota. The demand price of quota is equal to the sum of future cashflows less adjustment costs, the cost of producing the additional milk.

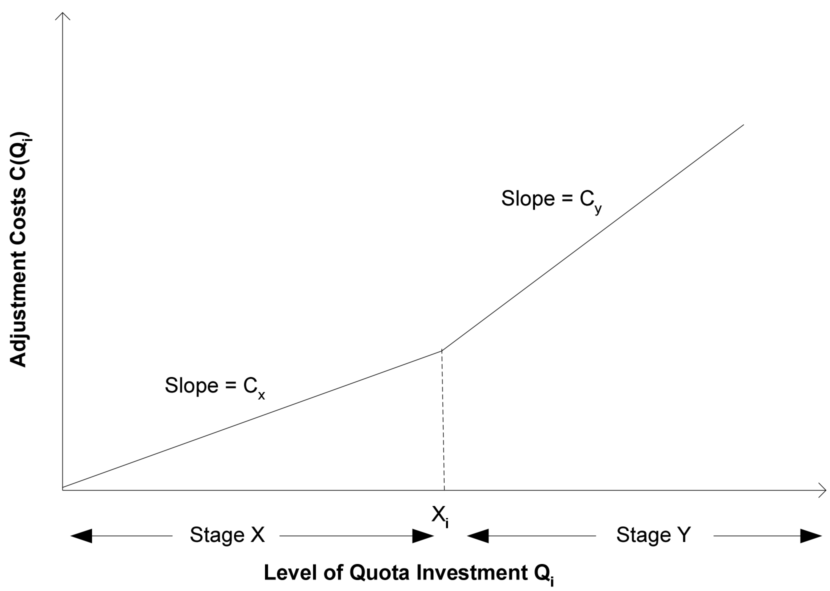
The adjustment costs $C(Q_{it})$ associated with purchase of Q_{it} units of milk quota differ depending on the stage of expansion. In this analysis adjustment costs are modelled as a piece-wise function where it is assumed that farmers can expand milk production through two stages, X and Y. This structure is illustrated in Figure 4.1. The marginal adjustment costs per litre associated with each stage of expansion and the extent to which each stage is feasible varies by farm depending on existing resources and efficiency. The adjustment costs associated with farm *i*'s investment in Q_i quota can be written as:

$$C(Q_i) = \begin{cases} C_{ix}(Q_i) & \text{if } Q_i \le X_i \\ C_{ix}(X_i) + C_{iy}(Q_i - X_i) & \text{if } Q_i > X_i \end{cases} \qquad (11)$$

With $C_{ix} < C_{iy}$

The marginal adjustment cost for farm *i* is C_{ix} in the first stage (Stage *X*) and C_{iy} in the second expansion stage (Stage *Y*). The first range of expansion (*X*) involves enterprise substitution (typically substitution of dairy cows for beef cattle). The costs associated with this stage of expansion include foregone profit from the beef enterprise, addtional heifer replacement costs and modest infrastructural costs.

Figure 4.1. The Structure of Adjustment Costs in the Analysis



The second stage of expansion (*Y*) occurs after investment in additional quota exceeds the threshold X_i. This point is determined by the farm's resource endowment and reprsents the maximum expansion of the farm's dairy enterprise that can be achieved through enterprise substitution. After point X_i, further expansion (Stage *Y*) requires more substantial investment in terms of acquiring additional land and the construction of new infrastructure. Consequently, marginal adjustment costs in stage *Y* are considerably higher than in Stage *X*. In the empirical analysis, the costs associated with each stage of expansion are taken from Shalloo et al (2006). The full details of costs associated with each stage of expansion are outlined in Appendix 1.

Once the expansion costs have been calculated the economic value associated with Q_i can be estimated for each farmer *i*. If X_i < 80,000 litres then a farmer will have two economic values one associated with stage X and another with stage Y, where $X_i \geq$ 80,000 only one economic value applies. By applying the aggregation factors from the NFS dataset to the economic sale and purchase values it is possible to aggregate the total amount of quota that would be purchased or sold at various prices, allowing us to derive aggregate demand and supply schedules.

4.4.1. Scenarios Modelled

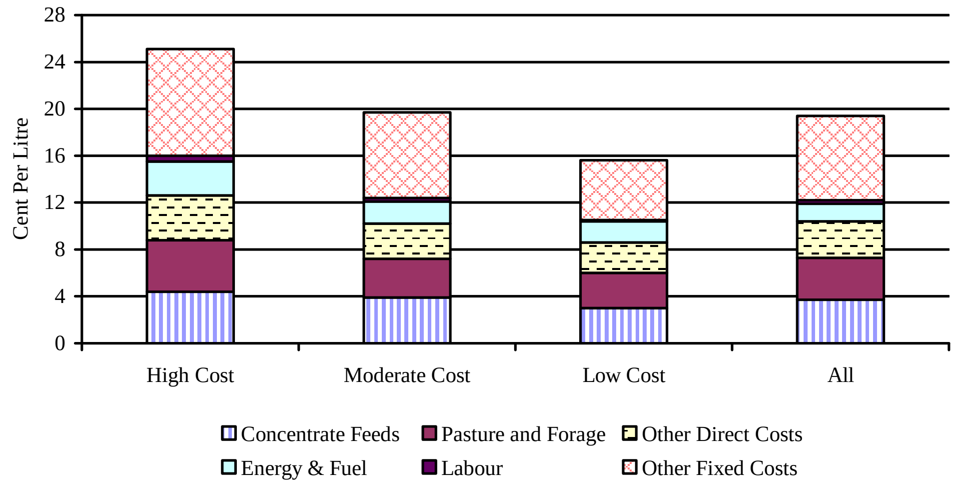
Two types of scenarios are modelled; the first pertains to quota trade and the second to EU milk quota policy. Quota trade is simulated in a national trade scenario and a regional scenario. Four regions are modelled; the Border Midlands and West as one region (BMW), the South West (SW), the South (S) and the East (E). For the national trade scenario all observations are pooled regardless of their geographic location.

Two EU milk quota policy scenarios are modelled; a baseline scenario assuming the current EU milk quota remains binding until 2015 and a quota reform scenario. In 2007 the FAPRI-Ireland Partnership conducted analysis of a milk quota reform scenario. The scenario assumes that the EU milk quota is gradually expanded by 3 percent each year from 2008 to 2015. The price and cost projections produced by the FAPRI-Ireland study, Binfield et al (2007), are used here to investigate the impact of milk quota expansion on the economic value for quota and the efficiency of the sector.

4.4.2. Data

The farm dataset consists of 343 farms that are weighted to represent approximately 20,000 dairy farms (Connolly et al 2006). Costs of production, and as a consequence profit, differ considerably across the sample. Figure 4.2 disaggregates the sample on the basis of cost efficiency. In 2006 the national average cost of production was approximately 20 cent per litre (CPL) but costs varied from 25 CPL on high cost farms to 16 CPL on low cost farms.

Figure 4. 2: Variation in Total Costs of Milk Production across all Creamery Milk Producers in Ireland in 2006



Source: National Farm Survey (2006)

To investigate the implications of regionalising quota trade, four regional quota markets are simulated. Table 4.1 presents some summary statistics for the four regions. On a gross margin basis, the East region has the highest profitability, with a gross margin of 17.3 CPL, however when overhead costs are factored in and net margin is considered the SW it the most profitable region with an average net margin of 7.4 CPL. The East has the largest expansion capacity on existing resources with the average farm having capacity for 24 additional cows.

Table 4.1: Regional Variability – Summary Statistics for four regions modelled

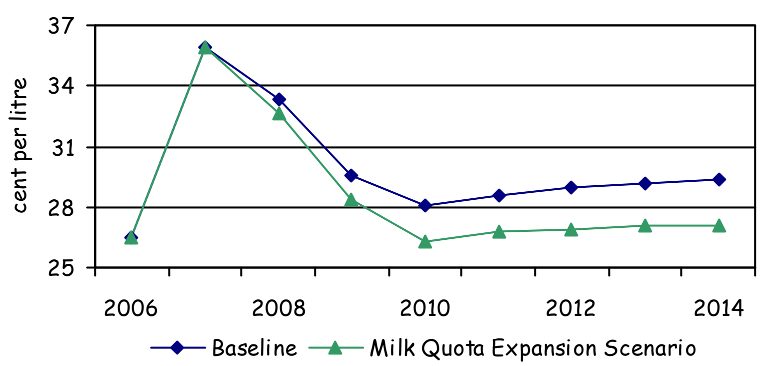
Summary Statistics	**BMW** ***N=65***	**SW** ***N=76***	**East** ***N=80***	**South** ***N=122***
Percentage of Farms (%)	25	30	14	31
Percentage of national quota (%)	21	30	15	34

Total Quota (millions of litres)	906	1234	651	1430
Average quota size (litres)	210,000	200,000	255,000	258,000
Average yield per cow (litres)	4,800	4,300	4,600	4,800
Average gross margin per litre (€)	0.169	0.166	0.173	0.156
Average net margin per litre (€)	0.062	0.074	0.068	0.061
Expansion capacity cow numbers	11	15	24	16

Source: National Farm Survey (2006)

Figure 4.3 presents the milk price projections under the baseline and the milk quota expansion scenario. It is estimated that under both scenarios milk prices will fall from the peak experienced in 2007. As expected, the price falls faster under the milk quota expansion scenario as supply increases across the EU. It is estimated that by 2014 milk supply in Ireland will have increased by 21 percent compared to the baseline and as a result milk price would be 8 percent lower.

Figure 4.3: Irish Farm-Level Milk Price Projections Baseline and Milk Quota Expansion Scenario

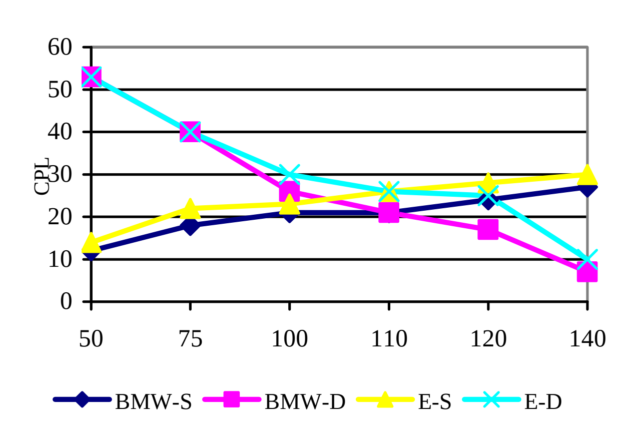


Source: Binfield et al (2007).

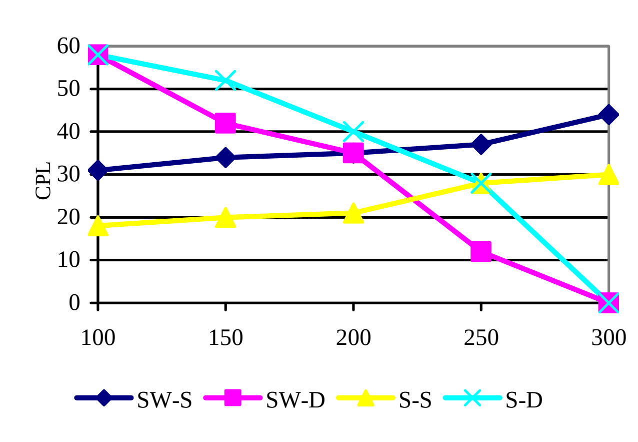
4.5. Results

Figure 4.4 presents milk quota supply and demand curves in 2008 for the four regional quota markets. The results show the equilibrium quota trade price in the BMW region is approximately 21CPL compared to a price of 26 CPL in the East. The markets in the South West and South are much larger and the equilibrium prices are higher. The equilibrium price in the SW region is the highest at 35 CPL and the trade price in the South is 29 CPL.

Figure 4.4: Regional Milk Quota Market – Trade in Millions of Litres



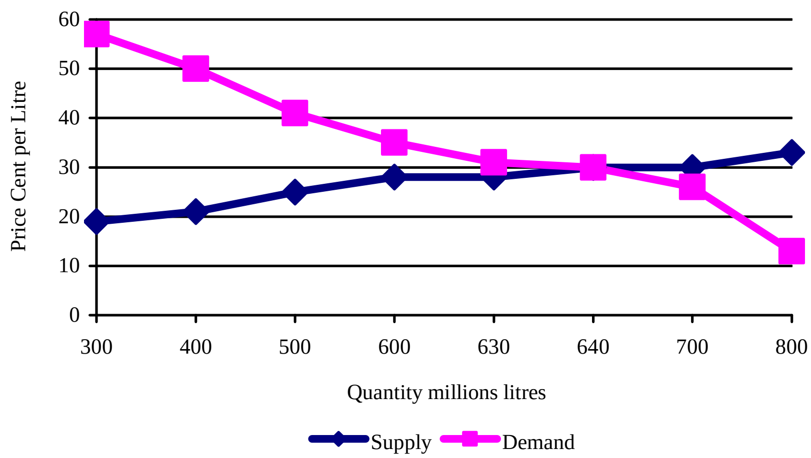
BMW and East Regions



SW and South Regions

Figure 4.5 presents the equilibrium trade price when quota is traded nationally. The results show that the equilibrium trade price is 30 CPL and approximately 650m litres of milk are traded.

Figure 4.5: National Milk Quota Market



It can be inferred that if Ireland shifted to national milk quota trade, quota would move out of the BMW and East regions and into the South West in particular. The farm-level model can be used to ascertain the implications for farm numbers and the location of production if quota was traded nationally. In the profit maximising model all farmers with a milk quota value below the equilibrium price would sell quota while all those with values greater than the equilibrium would find it profitable to purchase milk quota. Using this model it is possible to estimate changes in farm numbers and quota movement as a consequence of moving from a regional quota market to a national quota market. Table 4.2 shows projections of farm numbers under the two quota trade scenarios. Farm numbers fall faster, by 2.5 percent more, when quota is traded nationally rather than regionally and farm numbers decline more in the BMW and East regions and less in the South West. There is almost no change in the South.

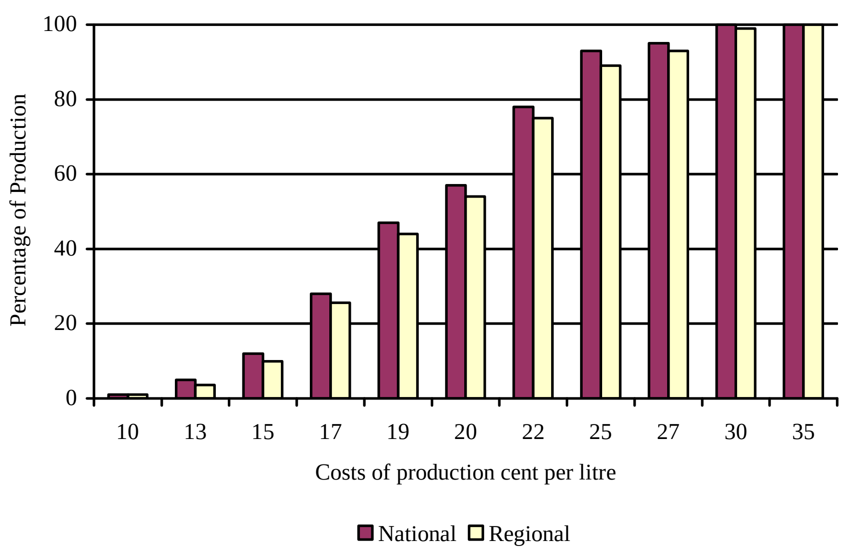
Table 4.2: The Implications of a National Milk Quota Market for Farm Numbers

Weighted Farm Numbers	2006 Base	Regional Exchange	National Exchange	Change Regional to National (%)
Nationally	19,600	15,739	15,353	-2.5
BMW	4,890	4,332	3,845	-12
SW	5,961	4,770	5,238	+10

East	2,769	2,349	1,998	-15
South	5,948	4,342	4,271	-1

Previous research suggests that more liberal trade of milk quota leads to more efficient outcomes. Here this hypothesis is tested empirically by comparing the cumulative cost curves for the sector under regional and national trade. Drawing on work conducted by Colman and Zhuang (2006) farm survey data is used to rank producers in ascending order of cost per litre of production and the cumulative amount of milk produced below any particular cost is calculated and plotted. Figure 4.6 presents the cumulative cost function for the Irish dairy farming sector under national and regional quota markets. The cumulative cost functions include the total costs of production, direct plus overhead costs as well as quota purchase costs in 2008 which are discounted over the seven year period to quota abolition in 2015.

Figure 4.6: Cumulative Cost of Irish Milk Production Cent per Litre – 2006 and quota trade scenarios

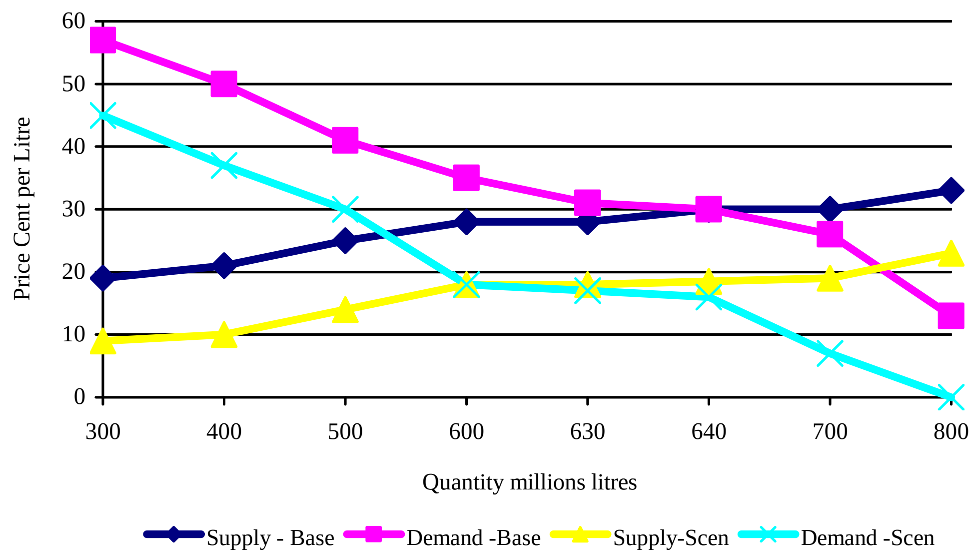


The cost curves are very similar but as is evident production is at a slightly lower cost under national trade. For example, for a total cost of production of 25 cent per litre 93 percent of milk is produced under national trade compared to 89 percent under regional trade. The total cost of producing the national milk supply can be estimated for the two scenarios. Under national trade the milk supply would be produced for €817.5 million while the cost under the regional scenario is €837.5 million, approximately €20 million or 2.5 percent higher. It follows then that the practice of ring-fencing quota trade to particular regions introduces an inefficiency of approximately €20million.

4.5.1. Implications of Policy Uncertainty

This section of the paper explores the effect of an expansion in the EU milk quota on the economic value of quota in Ireland. The milk price projections for the baseline and milk quota expansion scenario, outlined earlier in the paper, are used to estimate the economic value of quota in a national market under the baseline and milk quota expansion scenarios. The price projections show that the milk price declines faster under the milk quota expansion scenario as the additional milk supply dampens the price. It is therefore expected that the quantity of quota demanded is likely to be lower under the quota expansion scenario than the baseline, because the profitability of production has declined and because farmers have access to "free quota" under this policy reform and thus their capacity for additional expansion diminishes. It therefore follows that demand will be lower at any given price. Figure 4.7 presents the quota trade prices in a national market under the baseline and milk quota expansion scenarios.

Figure 4.7: National Milk Quota Market: Baseline and Milk Quota Expansion Scenarios



As is evident from Figure 4.7 the trade price of quota would decline significantly if a policy of gradual quota expansion was implemented. It is estimated that in a national exchange the trade price would decline from 30 cent per litre to 18 cent per litre. If farmers are operating under a false certainty that quotas will remain binding until 2015 but if the outcome of the CAP Health Check involves a quota expansion policy like the one analysed here, then farmers will have over paid for quota by up to 12 cent per litre on almost 640 million litres. This policy uncertainty imposes a considerable additional quota cost on the sector, based on the trade quantity of 640 million litres the cost is in the order of€76.8million.

4.6. Discussion

The results presented in this paper support the theory that the more freely quota is traded, the more efficient the outcome for the sector as a whole. It is estimated that the regionalisation of milk quota trade in Ireland causes an approximate €20 million efficiency loss to the dairy farm sector. This is cause for concern especially in the context of EU quota expansion or removal. Research has shown that Ireland is well placed to prosper following the elimination of milk quotas in 2015 (Binfield et al 2007). However, it is clear that the efficiency of the sector as a whole would be better served if a national market for milk quota was implemented in the intervening period between now and quota elimination.

The analysis presented above develops a framework to demonstrate the inefficiencies of regionalised trade. However, the inefficiency estimate (€20 million) should be interpreted with caution. This paper estimates the economic value of quota rather than the trade price. If the regional divergence in quota price is greater than estimated here, then the efficiency loss will be greater. In the analysis presented above, quota values range from 35 CPL to 21 CPL, however data on quota trade in Ireland show a range of 45 CPL in the south to 12 CPL in the west. Given that the divergence between quota prices is larger than the estimated here, it can be concluded that the efficiency loss is greater. The pertinent question then is; why the difference between the economic value of quota and the price.

There are a number of reasons why the economic value of quota will differ from the price. These reasons relate to the data and methodology, farmer behaviour and other uncaptured factors. In relation to data, the sample used could only be robustly disaggregated into 4 regions. In reality, quota trades in over 20 local areas, and therefore the quota trade prices are likely to reflect the local conditions more accurately than the data used. The methodology for estimating quota value is based on the axioms of profit maximisation and perfect certainty. It is assumed that farmers are fully aware of their production costs and have perfect certainty of future prices and that they behave to maximise profit under these conditions. As a result non-profit maximising behaviour is not simulated and therefore, the analysis does not account for farmers bidding uneconomical prices for quota. The recent quota trade price of 45 CPL recorded in the south of Ireland suggests that many farmers are bidding over their personal economic quota value.

There are a number of factors influencing farmers' behaviour that cannot be captured in a profit maximising model. Evidence from co-operative supplier numbers suggests that farm-level structural change has been more rapid in the border and west of Ireland over the past decade and as such expanding farmers in these regions have their demand satisfied. Structural change has been more sluggish in the south and east meaning farmers wishing to expand in these regions have pent-up demand. Anecdotal evidence suggests that there is a greater frustration with the regionalised system in these regions and farmers are determined to acquire quota. The prevailing quota price data suggests that this determination may be at an economic loss when one considers the profitability of production in these regions. It is very difficult for an economic study such as this one to capture these sentiments and to quantify their effect on the quota trade price. If data permitted a more detailed analysis of the impact of farmer behaviour on quota trade prices would prove an interesting area of further research and may be very relevant in the future if auctions for polluting licences, such as carbon permits, become a common element of agricultural policy.

The factors outlined above in relation to farmer behaviour may lead us to underestimate the inefficiencies associated with quota trade, however the irrefutable conclusion remains that regionalised quota trade results in efficiency losses for the sector. While the paper focuses exclusively on these losses, the welfare and equity implications of such a system should not go unmentioned. As the quota exchange system now operates in Ireland, a retiring or exiting farmer in some southern regions could sell quota for up to 45 CPL while in other regions retiring farmers would receive 12 CPL. This situation has substantial equity and welfare issues. The farming press and the lobby groups in Ireland seem to prioritise the interests of the expanding farmers by calling for lower quota prices. Exiting and retiring farmers interests seem to be less articulated. A welfare analysis of the regionalisation of milk quota trade would prove an interesting area of further research.

Finally this paper also explores the adverse effects of policy uncertainty. A methodological framework is developed to quantify the cost of an early abolition/expansion of quota in the EU. The results show that if farmers are unaware of policy changes and/or they receive insufficient notice about the changes that they will pay inappropriate prices for quota. This introduces an additional cost to the sector and a subsequent inefficiency. The results highlight the importance to disseminating information about policy change to farmers as soon as possible.

CHAPTER 6

MODELLING MILK QUOTA TRADE

6.1. Introduction

A major change in dairy policy happened in Ireland at the beginning of 2007 when a new quota trade system, Quota Exchange Programme, was first introduced. The new programme is market oriented in nature in contrast to a government based system in previous quota trades. It allows farmers to bid for buying or selling milk quota at their own prices. A market clearing price is calculated based on these bids and quota are traded at that price. This is a major departure from the earlier trade systems where quota trading prices were set by the Department of Agriculture. However, this programme still continues with a ring fenced quota trade like previous trade systems. In Ireland, all dairy farmers are contracted to a milk processor and under this ring fencing, quota trade is allowed only between participating farmers within a milk processing area.

Further changes in dairy quota policy in Ireland are inevitable following the decision to abolish milk quota from EU member states by 2015. These changes would aim at softening the impact of quota abolition on dairy sector in Ireland. Some possible changes have already been identified such as removal of ring fencing, progressive increase in quota quantity, decreasing quota price and removing super levy. Among these possible changes, the removal of ring fencing in quota trade can be considered as the most immediate change which has a potential to increase efficiency in national milk production and also assumed to have the lowest negative impact on farm income. Hence, in this study, we aim to determine possible impacts of removal of ring fencing on Irish dairy sector. We used a simulation technique to examine such an impact under two milk quota trade scenarios; first a regional trade where ring fencing is widened to a particular region and then a national trade where ring fencing is removed entirely and a free quota trade was allowed in the country. We first used a multi period deterministic model to arrive at market clearing prices and then used a farm level static linear programming model to simulate quota trade under these scenarios.

The following section reviews different approaches taken to simulate future quota trade in the EU and later sections describe the methodology used for the simulation of quota trade and provide results for the two trade scenarios especially looking at the changes on farm number, milk production and farm income.

6.2. Approaches taken to determine impacts of quota trade

Since last few years, many studies have been done in different member states of the EU to analyse changes in dairy policy. Studies on quota trade and quota removal comprise the majority of these works. Most of these studies used either econometric or mathematical models. Boots et al. (1997) used an econometric model to simulate different trade scenarios to analyze efficiency loss due to distortions in Dutch milk quota trade. Sckokai (2003) also used econometric models to estimate quota supply functions under tradable milk quota in three dairy regions in Italy. An EU consortium of French and Dutch researchers used an integrated production and processing/demand models to study impacts of possible changes in milk quota policy for the preparation of the EU commission's report (EU Commission, 2002). Most of the models stated above calculate a profit function through inputs and outputs parameter used on a farm. Although the models work fine for a profit maximising farm, yet by using fixed input-output coefficients, these econometric models loose flexibility to change management practices on a farm hence changing these coefficients. This makes the econometric models very rigid on farmers' decision making on farms. For instance, a farmer can change feed regimes to produce same level of yield but at a different input costs. Similarly, under an unconstrained quota trade scenario, input costs are the only constrained placed over the milk production whereas in reality stocking rate and availability of labour are also some of the limiting resources on farm. As pointed out by Yates and Rehman (2002) econometric models rely too much upon estimates based on observed results and not best suited for future policy impact studies.

A wide range of mathematical programming models has also been used in quota policy studies ranging from a globally oriented aggregated models (Boumamra et al., 2002; Lips and Rieder, 2005; EU Commission, 2008) to a more farm based models (Boots et al., 1997; Heuttel et al., 2005). The aggregated models (general and partial equilibrium models) are used in quota trade at a regional, national level as well as international trade under different trade scenarios. For example, Lips and Rieder (2005) used a modified GTAP model to analyse possible abolition of quota trade from the EU. They used dairy products as one of the commodities traded between EU member states, the US, oceanic countries and rest of the world and simulated a scenario where milk quota is removed from the EU. They showed that Ireland would increase milk production by 38% when milk quota is abolished. Similarly, a partially equilibrium model, DRAM, was used by Dutch researchers incorporated with an Input-Output (IO) model to simulate quota abolition in the Netherlands at the regional level (Helming and Peerlings, 2003). The model differentiates 14 regions in the country and suggested that under total abolition of milk quota, milk production would increase by up to 11% and dairy would substitute a large part of arable production from the north, middle and south-west of the Netherlands. More recently, a partial equilibrium model was used by researchers to analyse the impact of a number of policy options regarding the abolition of milk quota from the EU (EU commission, 2008) study. This study also was based on trading of dairy products between EU countries and other major dairy trading counties of the world. This study provided simulated results for different quota removal scenarios such as annual quota increase (1% and 2%) till 2015 when quota is abolished and a sudden quota removal (in 2009 and in 2015). The study suggests that under the gradual increase scenario, EU countries will have mixed type of impact, for instance Ireland will increase production to meet annual quota increase where as the production in the UK will decrease. Under the sudden quota removal scenario, the EU production is projected to increase by 5% in the first year with a consequence on decrease in milk price (-10%).

The equilibrium models are able to provide a good analysis for the policy impact on dairy sector in these studies. However, as these models only take aggregate values for different parameters used for the study, they are not suitable at farm levels especially when the objective of the study is to determine impact on different farm types and structural change at a disaggregated level. Farm level models are the mathematical models which are disaggregate in nature and a choice of technique when the policy impact studies need to be focused at individual farm level. However, it requires a large quantity of data which makes it less worthy if such data is not available. Only a few studies have been carried out in the dairy sector to determine the effects of quota trade using farm level models. The ongoing trade negotiations for WTO agreement could be one of the reasons why the majority of policy impact studies used aggregated models and focused on international trade and market prices. Aggregated models are much better suited for trade policies in between trading nations. However, a study on an impact of a new policy can only be complete if farmers' responses at the farm level are also carried out.

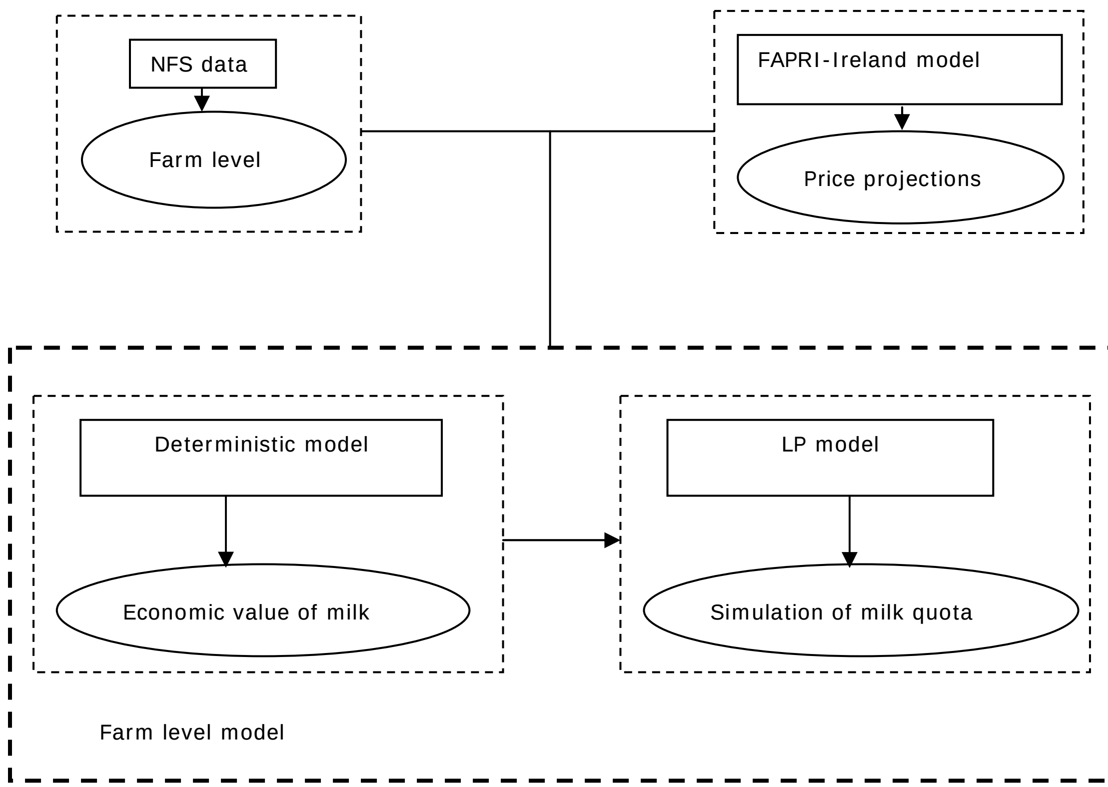
German researchers have used a farm level comparative static model, FARMIS, to simulate quota trade in Germany and France which is later on extended to other member states (Huettel et al., 2005). This model is an optimising farm level model which was disaggregated to representative farm group level. The model was used on farm groups rather than individual farms to reduce data errors and ensure farm confidentiality. The model used endogenously generated marginal price of quota as a criteria to trade milk quota between farm groups. The model successfully projected quota movement between different regions and also structural change occurred in dairy sector in these regions. The results showed a tendency for small farms to reduce milk production in both countries.

For our own study, we selected farm level optimising models because our aims are to examine the impact of a quota trade under different market restrictions and determine if quota moves from one area to another as well as any structural change that may ensues. Although we used a farm level model as the German work, our farm model is more disaggregated in nature. As stated earlier, FARMIS used averaged farm level data for a representative farm in a farm group; a lot of detail on response of individual farms is lost. The small farms which are reducing production cannot be identified on their production level or efficiency level as while forming farm groups, the FARMIS used region, size and system as stratification criteria. As agricultural farms are multidimensional (different levels of production, management, expenditures and profits) in nature, it makes them widely diverse from each other even if they are similar in one or two characteristics. There could be a number of sub groups within a group is such cases. For example, our earlier study showed there were at least 4 different sub groups of large dairy farms in south region of Ireland when 6 criteria (region, system, size, production level, farm income and family labour) were used in a cluster analysis (Shrestha and Hennessy, 2006). Those sub groups were similar in farm size but differed widely in production level and farm income and showed different extent of impacts of policy change on farm profits. Hence, grouping them based on only few criteria would overlook many issues in analysing impacts of policy changes on farms. For that reason, we used disaggregated data at individual farm levels in the study which allowed us to explore the impact of quota trade in more detail. Another difference in our methodology is the use of a multi period deterministic model in determining quota market clearing price and incorporating that price into the farm level model. This enabled us to simulate the quota trade based on the quota value not just for the modelled single year but on a number of years when quota still exists.

6.3. Methodology

A schematic diagram of the methodology is presented in Figure 6.1. The first step of this methodology is to integrate farm level data taken from the 2004 Irish National Farm Survey, NFS (Connolly et al., 2005) and price projections from FAPRI-Ireland model (Binfield et al., 2003) into a multi-period deterministic model to determine milk quota equilibrium price. This is the market clearing price where quota is assumed to be traded. This price is then used in the LP model along with farm level data to simulate milk quota trade under different market scenarios. The LP model optimises the farm margin by either buying or selling milk quota at this equilibrium price. Brief descriptions of the models are provided below. Two different market scenarios; i) the regional trade scenario where quota trade is restricted within designated regions and ii) the national trade scenario which is a free market where no such trade restriction is applied; are used to simulate milk quota trade in Ireland.

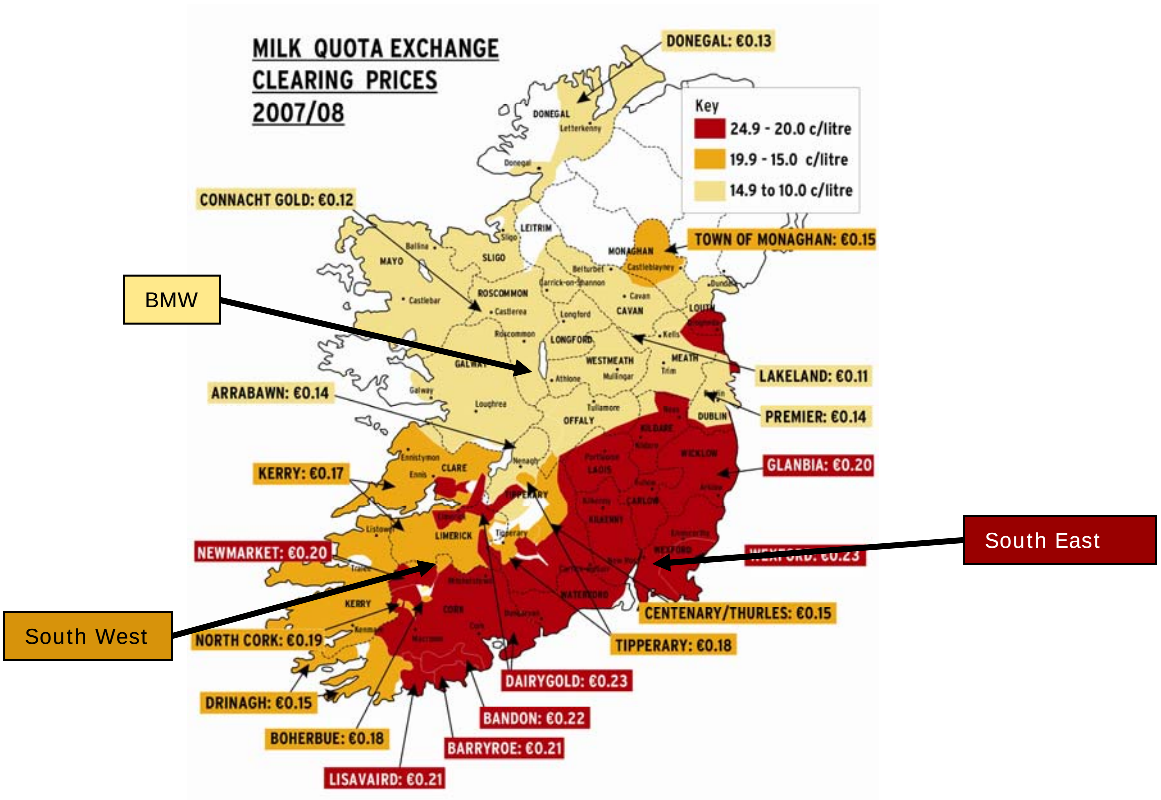
Figure 6.1: Schematic diagram of the methodology



6.3.1. Farm level data

Farm level data from dairy farms from the NFS 2004, was used for this study. Farms were first separated in three arbitrary but distinctive dairy regions; BMW, South East and South West. These regions are identified based on market clearing prices from the First Exchange programme (Figure 6.2). Farm level data was available for 119 farms in the BWM, 254 farms in the South East and 85 farms in the South West regions. These data were then aggregated to regional levels by using regional weighting factors provided by the NFS.

Figure 6.2: The first quota exchange 2007-08 (source: Farmers Journal, 2007)



6.3.2. Models

Multi-period deterministic model: emphasising on equilibrium price

The model determines milk quota selling and buying prices for individual farms included in the survey and upgrades the results to a regional or national level by aggregating them using regional and national weights. The model considers four major factors to arrive to an estimated quota value, they are; (i) the outlook for milk prices, (ii) costs of production, (iii) the number of years that the quota will produce a profit, and (iv) the cost of producing the additional milk. These four factors determine the value of quota and therefore should guide any farmer's calculation on what to pay for quota if expanding production and what to accept for quota if exiting production. Price indices from the FAPRI-Ireland model is used to project different prices and costs from 2006 to 2015 when quota is assumed to be abolished. By using the outlook for prices and costs of different producers it is possible to determine (i) the minimum breakeven price that a farmer should accept if selling quota by using equation *1*; and (ii) the maximum affordable price a farmer can bid if expanding production by using equation *2*.

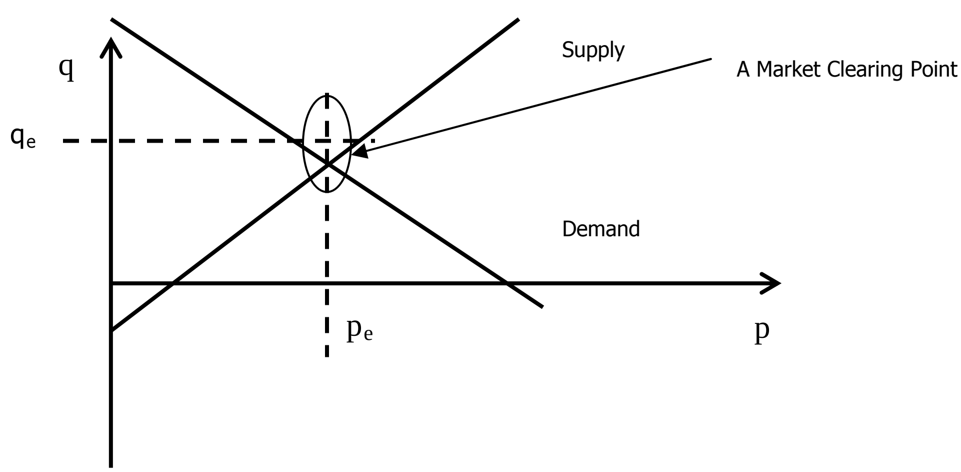
$$QVs = \sum_{t=1}^{n}(R_t - C_t) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

$$QVd = \sum_{t=1}^{n}(R_t - C_t - E_t) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

where, QVs = quota value for selling; QVd = quota value for buying; R_t = returns from per litre of milk; C_t = costs per litre of milk production; E_t = cost producing additional milk and t = number of years quota exists (1,…,n)

By aggregating these estimates using regional or national weights, it is possible to produce estimates of the regional or national supply of and demand for milk quota. These values can be plotted in a graph to determine an equivalent price i.e., a market clearing price. It is very important to note however that these estimates assume that farmers are profit maximisers and that they will only bid and accept prices that are economical. It should therefore be noted that this analysis will provide estimates of the value of quota rather than the actual price at which it may be traded.

Figure 6.3: A competitive market of milk quota trade



The value of quota can be measured economically but the price that will prevail in the market will vary depending on the willingness of farmers to buy quota at uneconomical prices either for reasons of utility or lack of knowledge of the true value of quota for their own situation. Here, the aggregated return from milk production after discounting for price deflation is assumed to be the economic value of quota. The aggregated figures for the supply and demand of milk quota are plotted in a graph to present normative curves (Figure 6.3). The point of intersection of the supply and demand curves provides us with an equilibrium price (p_e) and quantity traded (q_e) in a competitive market.

Linear Programming (LP) model: simulating quota trade

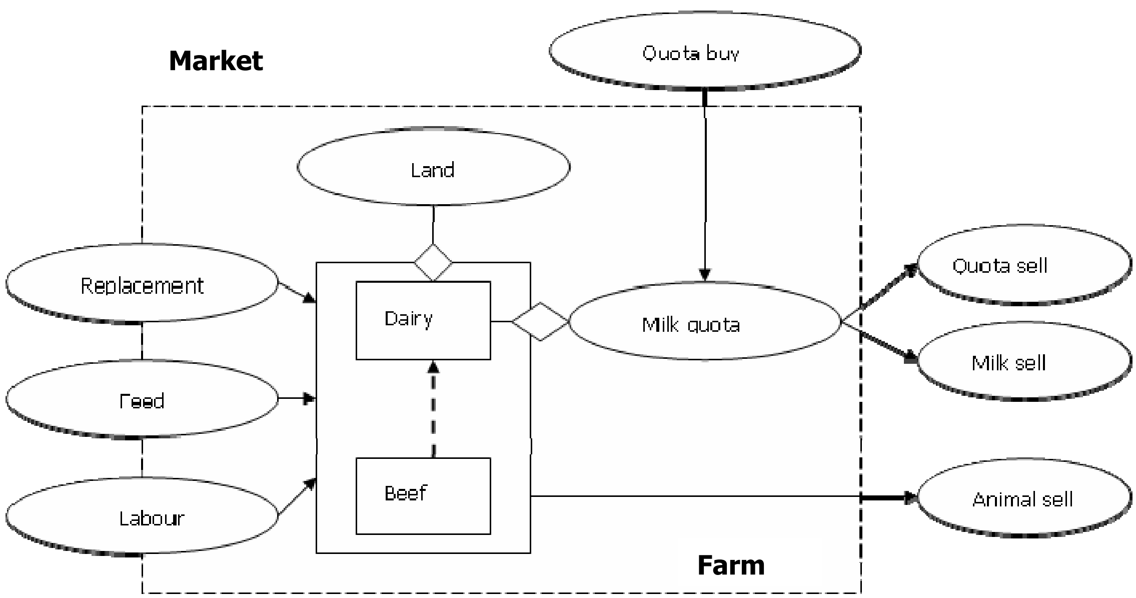
A farm level static linear programming (LP) model is developed for the study to determine the quota movement within an area of interest. That area of interest could be a region or a nation. A LP model operates by maximising or minimising an objective function subject to a number of constraints. In this case, farm gross margin (z) for a region with f farms was maximised within the constraint of the limiting resources $R_{f.}$ The general form of the model is;

$$\text{Max } z = \Sigma (p_f * x_f) - (c_f * x_f)$$
$$\text{s.t.} \quad A_f * x_f \leq R_f$$
$$x_f \geq 0$$

where, x_f is the farm activities for farm type f, p_f is a measure of the returns and c_f are the costs procured for x_f activity, A_f is an input – output coefficient for activity x_f, while R_f is a limiting resource such as milk quota, land and labour

A schematic diagram of the LP model used for this study is presented in Figure 6 where a dotted rectangle represents a farm outside which is a market. Livestock activity (dairy and beef) is the core part of the model with outputs (milk and animals) from this activity going to the market. All other farm activities such as grass production, stock replacement and labour management take place to support the livestock activity. The model allows a farm to have dairy and beef animals on farm which are mutually replaceable. For the Irish context, the land transfer between farms in not included in the model and it is assumed that only a maximum of 50% of the beef animals can be replaced by the dairy animals on existing farm land. However, land transfer activity can be included in the model if there is a possibility of land transfer activity between farms. It is also assumed that a farm can expand milk production through two stages; the first stage where the farm can accommodate additional dairy animals without incurring major investments; and the second stage where any further addition in animals will require adjustment costs such building costs (€300/cow) and bulk tank costs (€520/cow) for each of the additional dairy cow.

Figure 6.4: A schematic diagram of the farm level LP model



The number of livestock on a farm is constrained by a stocking rate on available farm land. The stocking rate is based on the farm level NFS data for individual farms and is fixed for each farm. As both stocking rate and land on a farm are fixed, the only way to increase animal numbers on a farm is by replacing other types of animals. Farm land can be used both for grazing and silage production however it is assumed that grassland can be used only up to 50% of total land for conserving grass. Grass, grass silage and concentrate are the main feeds available to the livestock. The model allots these feeds to animals based on their energy, protein and dry matter intake requirements. This is determined by type, age and production level of an individual animal (Alderman and Cottrill, 1993). A minimum level of concentrate is used on farm to maintain milk yield level which is also taken from the farm level data for each farm. All of the concentrate feed used on farm is bought in while grass silage is either produced on farm or bought in. Each farm activity in the model (dairy, beef and grass conservation activities) requires a level of labour which is based on farm management handbook (Teagasc, 2007). The model uses family as well as paid labour where required. All labour used in the model is assumed to be skilled labour suited for all farm activities.

As shown on Figure 6.4, besides resources that exists or produced within a farm such as land and grass, a farm bring in additional resources such as milk quota, animal replacements, feed (concentrate and grass silage) and hired labour from the market while milk quota, animals and milk are the farm's output that is sold to the market. Farmers selling milk quota have to sell dairy animals as well, as they are not allowed to produce without a quota and will be unprofitable for a farm continue keeping them. The model assumes farmers receiving optimum price for the sold animals based on the NFS data. However, it should be noted that in reality there is always a risk of receiving lower price at the time of selling when one is exiting the business (Pennings and Meulenberg, 1998).

Quota in the model

On an individual farm, milk production activity is constrained by quota level available to the farm. Total milk quota level available to a farm is taken from the NFS based on the total number of animals on farm and milk yield per animal. Farms are allowed to increase milk production by buying in or to exit dairy production by selling out milk quota. Transfer of milk quota is possible between farms at a regional or national level depending upon the model running at a regional or national level. Further constraints are placed on a possible transfer of the quota so that a farm can buy milk quota only if other farms are selling quota within a regional or national level, such as;

$$\sum^{n} \text{bquota}(f,y) \leq \sum^{n} \text{squota}(ff,y); \; \forall\, y$$

f=1 ff=1

where, bquota is bought quota; squota is sold quota; f is the n number of farm types; y is the number of years, and ff is an alias of f such that ff C f but ff ≠ f

To balance total quota present in the country, the model runs under a condition that total amounts of quota sell and quota buy are equal;

$\sum bquota(f,y) = \sum squota(f,y) \ \forall f, y$

Another condition in the model sets a quota selling farm to sell its entire quota or sells none to represent non-existence of marginal sale of quota in reality in Ireland. The LP model simulates quota movement within a well defined area such as at regional/national level based on the input data set. In the model, individual farms maximises farm profits individually within their limiting farm resources. Quota trade is the only link provided between farms within the area of interest. Because of its optimising property, the LP model would allow the milk quota to flow from farms making a loss to profitable farms which provides us an opportunity to explore the impact of a free market of quota trade on dairy farms. This also provides information about the farms which are exiting or expanding under a quota trade. Under the quota exchange programme in Ireland, there is a limit of a maximum of 80,000 l placed on bids for quota demanded. As this paper simulates a freer market, we removed this limit and run the model without any restrictions on bids placed by the farmers.

Trade Scenarios

There are two types of trade scenarios for this study; a regional trade scenario and a national trade scenario. As stated early, we identified three regions based on the First Exchange market clearing prices. The reason behind identifying these regions is to select regions where milk production differs from each other as much as possible. This allows us to see the impact of any changes in dairy policy in different production levels and we assumed that this will provide us with a better picture of quota movement from one distinctive region to another if ring fencing is removed. As we know from our previous works, quota moves from smaller farms to larger efficient farms when quota is allowed to be traded within a ring fenced area (Shrestha and Hennessy, 2008). The regional and national trade scenarios would allow us to determine if quota movement will follow a similar trend. If such movement exists then it will allow us to identify the direction of quota movement and quantify the amount of quota movement.

6.4. Results

6.4.1. Multi-period deterministic model

Using the regional aggregate weights, the model determined total milk production (supply) in the three study regions as shown in Table 3. The figures suggest that the BMW and South West regions share about 25% while the South East region shares remaining 50% of total milk production in the country. On the demand side, the model combined both forms of milk expansion as stated in earlier section (i.e., i. no major investment but increase yield with better management and ii. Replacing 50% of beef animals with dairy animals) and determined that a total of 3 bil l of milk quota is in demand nationally. The regional distribution of demand for quota follows similar proportions as of the national milk supply (Table 6.1).

Table 6.1: Characteristics of three dairy regions

	BMW	South East	South West
Total milk production (bil l)	1.3	2.7	1.3
Total demand (bil l)	0.7	1.7	0.6

For each of the regions, the aggregated supply and demand of milk quota was plotted against quota price as shown in Figure 6.5. The intersections of these two normative curves determined the market clearing (equilibrium) prices for the regions. The BMW has the lowest price at 11.5 cpl and the South West has the highest price at 18 cpl while the South East region has a price at 17.5 cpl.

Figure 6.5: Equilibrium price for three regions using normative supply (_S) and demand (_D) curves

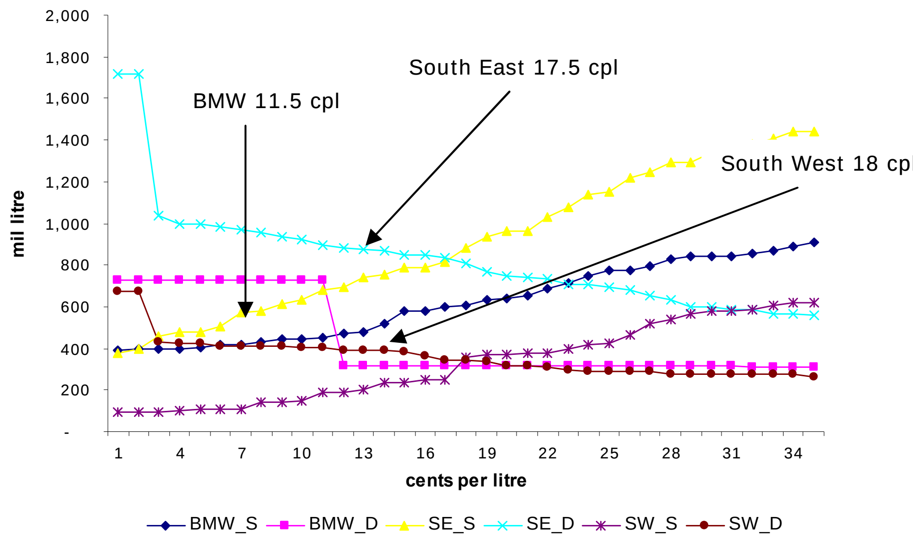
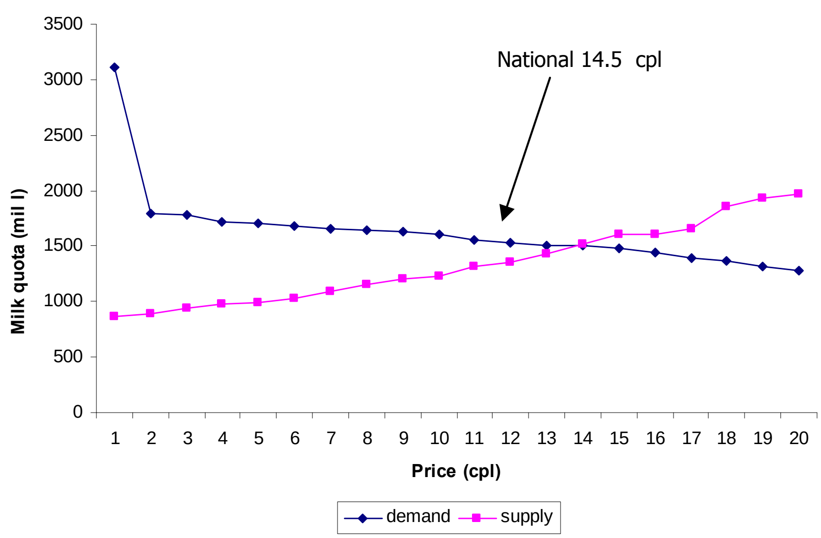


Figure 6.6: Quota equilibrium price for a pooled national supply and demand for milk quota



At these prices, the South East traded the highest amount of quota at 850 mil l followed by the BMW region at 450 mil l traded. Although the farms in the South West region have the highest market clearing price for quota, the amount traded is the lowest in the region compared to other two regions. To determine a national averaged quota clearing price, all demand and supply for quota in each of the regions are pooled together and once again plotted against milk quota price. This provided with a national equilibrium price of 14.5 cpl and a trade of 1.5 bil l quota at that price (Figure 6.6).

6.4.2. Milk production and farm number

Regional scenario

Under this scenario, regional market clearing prices estimated by the deterministic model (i.e, 11.5 cpl for the BMW, 17.5 cpl for the South East and 18 cpl for the South West regions), are used in the LP model. A total of 204,628,835 l quota is traded nationally. As shown in Table 6.2, South East region traded the highest quantity of quota (42%) than other two regions (BMW 32% and South West 26%). At the given quota clearing prices, there is only a small structural change in the Southern regions with less than 2% change in exiting and expanding farm numbers. However, in the BMW the expanding farms outnumbered exiting farms by 6%. This suggests that in this region there are few very large farms making loss which exited milk production covering the entire quota demand of the region.

Table 6.2: Total milk quota and number of farms expanding and exiting in the three regions

Regions (milk quota clearing price)	Expanding	Exiting
BMW (11.5 cpl)		
Quota traded (l)	66,364,588	" "
Number of farms (% of total farms)	736 (10%)	273(4%)
South East (17.5 cpl)		
Quota traded (l)	86,595,822	" "
Number of farms (% of total farms)	951 (8%)	780 (7%)
South West (18 cpl)		
Quota traded (l)	51,668,425	" "
Number of farms (% of total farms)	643 (9%)	827 (11%)

Based on the NFS, 2004 data, there are 26,700 dairy farms in Ireland and under the regional scenario, 7% of them are projected to exit dairy production and 96% are projected to expand. To determine the difference between exiting farms and rest of the farms regionally, a t-test is carried out on 11 farm variables for each region (Table 6.3).

The results show that in the BMW region, exiting farms are almost double in land size than remaining farms. These farms also had the lower milk yield per cow but higher replacement costs. These farms also have a highly significant number of beef animals on farms which might indicate a possibility for these farms to quit dairy farming but continue beef production. This possible transfer was not covered by the existing farm level model. In both of the Southern regions, the most significant farm variables in determining farms to exit or stay in dairy production are almost identical. Exiting farms characteristically have larger dairy numbers, higher milk yield, higher milk price and lower production costs. In general, milk yield is the most significant indicator for a dairy farm in all regions along with production costs in determining if the farm is staying or exiting dairy production.

Table 6.3: Characteristics of exiting farms compared with the remaining farms under regional trade

	Border		South East		South West	
	Exiting	Rest	Exiting	Rest	Exiting	Rest
Land (ha)	100.8**	54.1**	56.3	65.3	38.2	52.3
Dairy number (lu)	46	48	32**	57**	24**	46**
Beef number (lu)	76**	30**	44	41	19	26
Stocking rate (lu/ha)	1.3	1.5	1.3	1.5	1.2	1.4
Milk yield (l/cow)	3864**	5150**	3992**	5190**	2994**	4683**
Milk price (cpl)	0.25	0.25	0.24**	0.25**	0.24**	0.25**
Calf price (€)	167	188	225**	194**	211	200
Paid labour (man hr)	0.48	0.25	0.17	0.28	0.01	0.08
Replacement costs (€/cow)	1533**	1108**	1105	1190	1029	1089
Overhead costs (€/cow)	582	470	607*	497*	827**	398**
Direct costs (€/cow)	554	545	482	477	446	427

National scenario

In this scenario, the entire national farm data for dairy farms (#458 farms) from the NFS dataset is used. Once again, NFS weights were used on farms for their aggregation at the national level. The pooled national quota equilibrium price (i.e., 14.5 cpl) from the deterministic model is used and once again no restriction on the amount of total quota trade is set under this scenario. The model results shows that once the regional trade is widened to the national level, amount of traded quota is almost doubled to that of traded under regional scenario (Table 6.4). The quota trade in different regions is different compared to that under regional trade scenario. The national market clearing price is higher than regional market clearing price in the BMW hence as expected, quota supply is increased in this region under national scenario. The supply of milk quota was 44% higher than the demand for the quota in this region.

Table 6.4: Total milk quota and number of farms expanding and exiting in each region at an clearing price of 14.5cpl

Regions	**Expanding**	**Exiting**	**Difference**
BMW			
Quota amount	90,309,591	130,400,949	- 40,091,358
Number of farms (% of total farms)	1052 (14%)	829 (11%)	
South East			
Quota amount	235,395,446	212,496,788	+ 22,898,658
Number of farms (% of total farms)	2,252 (19%)	1,171 (10%)	
South West			
Quota amount	79,111,385	61,918,686	+ 17,192,699
Number of farms (% of total farms)	932 (13%)	923 (13%)	
Total quota traded		**404,816,423 l**	

While in both South East and South West regions, the demand for milk quota is greater than the supply. There is almost double the number of farms expanding in the South East region compared to the number of farms exiting dairy sector. However, the number of expanding and exiting farms is almost similar in the South West region. In the BMW region only 69% of the supply is taken up by expanding farms within the region and 31% of the supply went out of the region. In the South East region there is 10% more quota demanded than that supplied while in the South West region 22% of the quota is demanded more than the quota supplied. The higher demand from farms in the southern region and higher supply from farms in the BMW region suggests that milk quota would move from north to south if regional market is expanded to a national market. In the equilibrium condition, 57% of the over supplied quota from the BMW region would go to dairy farms in the South East region and rest of 43% would be taken up the dairy farms in the South West region.

Under this scenario, a total of 11% of dairy farms are projected to exit dairy production and 16% to expand nationally. The characteristics of farms exiting dairy production under the national scenario are very similar to those of farms exiting under regional scenario (Table 6.5). In the BMW region, types of farm variable that are significant in exiting dairy do not change much. The exiting farms are typical large farms with higher number of beef animals on farms, lower milk yield and higher production costs. Besides these variables, paid labour also became a significant characteristic with exiting farms having higher paid labour units under the national scenario. In the South East region, milk yield and dairy replacement costs are the most significant farm variable in deciding whether to quit dairy production or not. The price obtained for milk and female calves also play a significant role in quitting the production in this region. In the South West region, stocking rate and replacement costs are the most significant variable for farms to exit dairy production. Besides those variables, milk price obtained by the farms is also important in deciding to sell entire quota in this region. However, milk yield and over head costs did not stay as significant variables to decide in exiting dairy production anymore under the national scenario. However, In general, characteristics of exiting farms in the BMW remained the same as were under the regional scenario whereas in the southern regions, types of variables that would characterise the exiting are changed slightly. In the South East region, number of dairy animals on farm was not a differentiating characteristic anymore but cost of replacing dairy cows became a significant variable to make decision. Similarly, in the South West region, number of dairy animals and milk yield did not remain significant characteristics of the two sets of farms but stocking rate and replacement costs became significant.

Table 6.5: Characteristics of exiting farms compared with the remaining farms under national trade

	Border		**South East**		**South West**	
	Exiting	Rest	Exiting	Rest	Exiting	Rest
Land (ha)	86.9**	53.0**	71.4	64.3	60.9	50.4
Dairy number (lu)	57	47	48	56	32	45
Beef number (lu)	63**	29**	50	40	24	25
Stocking rate (lu/ha)	1.3	1.5	1.4	1.5	0.9**	1.4**
Milk yield (l/cow)	4127**	5193**	4286**	5205**	3904	4593
Milk price (cpl)	25.3	25.3	24.7*	25.3*	23.8*	25.0*
Calf price (€)	175	189	214*	195*	213	200
Paid labour (man hr)	0.78**	0.20**	0.27	0.27	0.19	0.07
Replacement costs (€/cow)	1440**	1094**	1565**	1149**	1410**	1059**

Overhead costs (€/cow)	607*	460*	515	505	553	424
Direct costs (€/cow)	552	545	498	475	346	434

6.4.3. Farm Net Margins

The farm net margin was another indicator that we selected to determine the changes under the two trade scenarios. In the BMW region, the national trade scenario seems to increase the number of farms with higher farm net margins compared to that under the regional trade scenario (Figure 6.7). Under regional scenario, only 30% of the farms were earning more than 30,000 a year which increased to 40% when a national trade was allowed. As the model was only run for one year the farm exiting dairy production still included in these groupings. In this region, the lower income group also consisted of a larger number of exiting farms compared to higher income groups under both scenarios. As shown in the figure, under the national scenario, the lower two income groups have 669 farms which sold their entire quota and exited dairy farming when quota trade moved from a regional to a national trade. In the top two income categories, there are 161 farms which moved up the income group by selling their quota.

Figure 6.7: Farm distribution under two trade scenarios based on farm net margin in the BMW region[5] [x-axis (farm net margins, €): 1 = 0 – 9999, 2 = 10000 – 29999, 3 = 30000 – 49999 and 4 = more than 50000]

[5] *Exiting farm numbers are for national scenario only.*

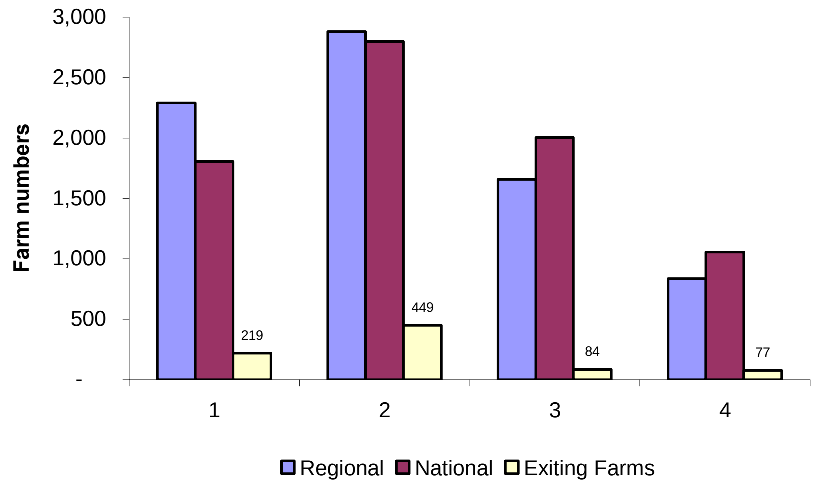
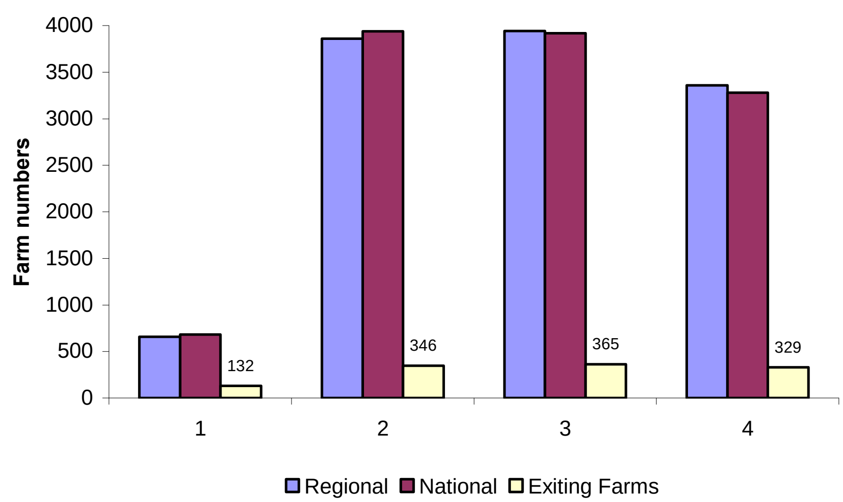


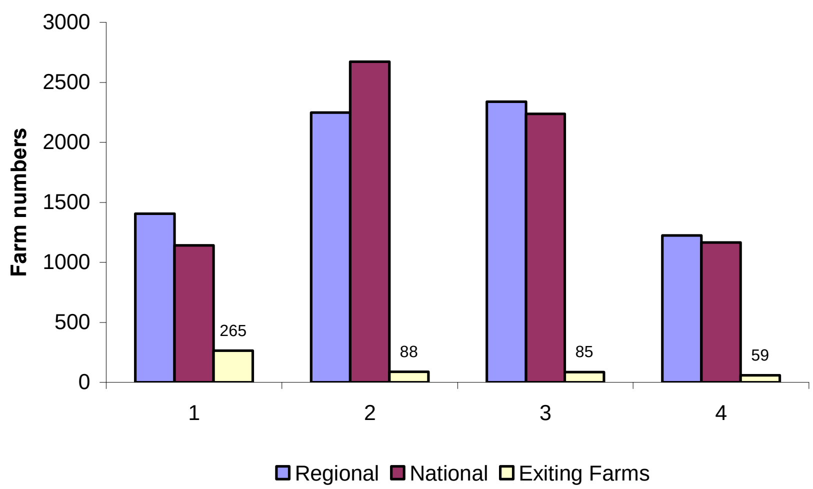
Figure 6.8. Farm distribution under two trade scenarios based on farm net margin in the South East region [x-axis (farm net margins, €): 1 = 0 – 9999, 2 = 10000 – 29999, 3 = 30000 – 49999 and 4 = more than 50000]



The South East region has the least number of farms earning below € 9999 than any other regions. Figure 6.8 shows much uniform distribution of number of farms in upper income groups. There is not much change in the farm numbers in different income groups under both the scenarios. However, it is interesting to see a decrease in the number of farms in the upper income groups. The reason behind that is with a decrease in quota price under national scenario more farms are able to buy quota which spread available quota over a wider number of farms. Hence some of the high income farms which were able to buy more quota under the regional scenario are not able to do so and they have a decrease in profits and move towards lower income group.

In the South West region, farm number in higher net margin groups remain almost same but farm number in the € 10,000 – € 29,999 increased by 6 % whereas number of farms in the less than € 10,000 group decreased by 4% (Figure 10). The lowest group consists of almost 18% of the farms that exited left dairy production under the national trade scenario. The highest income group had the lowest number of farms exiting the production.

Figure 6.9: Farm distribution under two trade scenarios based on farm net margin in the South West region [x-axis (farm net margins, €): 1 = 0 – 9999, 2 = 10000 – 29999, 3 = 30000 – 49999 and 4 = more than 50000]



Conclusions

The simulated results for a regional and national quota trade provided some insights on possible outlook of dairy sector in Ireland. Quota is expected to move out of less efficient farms (and regions) to efficient ones. This suggests that there will some extent of structural change in dairy sector when trade is widened to a regional or a national level. The model results confirms it and shows that under a regional quota trade there is a projection of 7% diary farms moving out of dairy production where as 9% of the farms will seek an expansion on production. Moving from a regional to a national quota trade will see a doubling of total amount of quota traded. The results project the farms in the southern regions to be more efficient producers as 31% of the total quota supplied in the BWM region would be taken up by the farms in the southern regions. The number of exiting farms also increases under the national trade scenario (11%) where as the number of expanding farms increase by 16%.

Would a removal of ring fence and a subsequent structural change have a positive effect on dairy sector in preparation for up coming quota abolition? The simulation definitely suggests that the wider ring fenced area is allowed, the more quota moves from un-profitable farms to efficient farms. This can be interpreted that if we remove ring fencing from the quota trade, a larger numbers of the less efficient farm would have an opportunity to exit dairy production before their quota asset becomes worthless. Similarly, profitable farms would have a greater opportunity to increase their production and improve their profits. For both sets of farms quota the effect of quota abolition can assume to be minimal as; for the first type of farms, they would have benefited from their quota value long way before it becomes worthless and for the second type, they already have an opportunity to increase production up to their optimal levels, would be better prepared when quota will not be a limiting factor anymore and have sufficient time to adjust for any possible decrease in milk price as a consequence of such change.

However, it should be noted here that our results show only a small portion of quota to be traded (14%) compared to total quota demand nationally even under a free national market. There is only 11% of farms exiting and 16% of farms expanding in that market condition. The model projected rest of 73% of farms to be profitable in varying degrees and remained unchanged under modelled conditions. Now the question can be asked how much impact quota abolition will have on these farms. Some of the farms in this category may be at a marginal profit level and might need additional measures besides the removal of ring fencing to minimise any negative effects of quota abolition.

CHAPTER 7

Profitable Production Systems in an Increased EU Milk Quota Scenario

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7.1 Summary

- Significant potential exists for expansion in output and profit on Irish dairy farms
- Successful systems while profitable, must also be sustainable in terms of staff, animals and the environment, and allow for a quality lifestyle and time-off.
- Profitable future farm systems must be simple, based on higher stocking rates, an appropriate mean calving date, high EBI genetics, proactive grassland management and effective use of supplements.
- The imposition of the technologies discussed herein has the potential to increase the profitability of milk production on Irish dairy farms by €1,800 per hectare.

7.2 Introduction

The Common Agricultural Policy (CAP) was introduced in Europe to ensure EU food security in a recovering post war EU economy by delivering higher less volatile prices to producers (Whetstone, 1999). By the late 1970s, milk production driven by high prices outstripped milk consumption and on that basis, in April 1984 a dissuasive super levy quota was introduced on individual producers which penalised supply beyond a fixed quota. Recent analysis carried out within EU has suggested that milk quotas are now constraining the development of an efficient European dairy industry (van Berkum and Helming, 2006). Dairy farming in Ireland is now at a crossroads. Behind us lies a farming environment where all farmers received a similar price for milk, milk prices were high and stable and emphasis was on maximising profit per litre of milk quota (Shalloo *et al.*, 2004). Ahead of us lies a quota free more volatile milk price environment, differentiated multiple component pricing, continued reform of EU agricultural policy and increased environmental regulation. A study by Lips and Rieder (2005) projected that quota abolition would allow production to move to areas of competitive advantage within Europe such as Denmark, Ireland and the Netherlands, predicting that milk production in Ireland could increase by up to 39% post quota.

Change will create opportunities for farmers to grow and redesign their businesses. Quota removal will require new innovative blueprints of milk production for dairy farmers capable of expanding milk production and taking cognisance of stronger international market forecasts for dairy products (OECD, 2007). The most profitable system of production will be that which gives the highest profit per unit of the most limiting input. When milk quotas are removed, other factors will become limiting such as land, stock, supplementary feed or labour availability thereby becoming the new quota. In such a scenario, technical innovation will be required as producers focus on achieving higher profit per hectare of farm land, per labour unit employed, per milking cow or per other farm specific factor. The challenge for Irish dairy farmers is to increase the competitiveness of their business through innovation, productivity gain and increased operational scale as the industry evolves.

Similar agricultural reforms have occurred in many other countries. The deregulation of the Australian industry began in 1999 and has resulted in a reduction in dairy farm numbers with international prices now determining the price received by farmers for their milk. In New Zealand, the subsidy system was removed in 1984 and stimulated an expansion in production with increases in cow numbers and land conversions from other enterprises to dairying (Davison, 1996), reductions in input costs (Blandford and Dewbre, 1994), increases in productivity as farmers reduced expenditure and redistributed resources to areas of comparative advantage (Philpott, 1995). The detailed information necessary to accurately estimate the capacity for increased milk production on Irish dairy farms is not readily available however based on National farm survey statistics (NFS, 2006) the current average herd size is 52 cows out of a total of 80 grazing livestock, on 40 hectares of land.

The objective of this paper is to explore and quantify the potential for expansion on Irish dairy farms based on survey analysis, to describe the characteristics of profitable farm systems in future and explain the required changes to the system in preparation for an environment free from the constraints of milk quota.

7.3 The Potential for Expansion on Irish dairy farms

A survey was carried on over 1,430 dairy farmers supplying Glanbia, Connacht Gold, Lakeland and Donegal throughout 2007. The Glanbia survey was carried out in January and February while Connacht Gold, Lakeland and Donegal surveys were carried out from July to October. The surveys were carried out over the telephone with the farmers being posted the survey prior to the telephone call, explaining the process and the requirement for the information. Seventy eight percent of the farmers contacted completed the survey. There was four objectives to the survey;

1. Determine what was the potential for expansion on dairy farmers in terms of land areas around the milking platforms as well as other parcels of land.
2. Determine what was the current labour availability and potential for a successor on dairy farms
3. Determine the current status in Winter housing and milking facilities
4. Determine what were the future in intentions of the farmers surveyed

Table 7.1 shows some of the biological and attitudinal responses to the survey. Average milk quota size and area around the grazing platform were larger for the Glanbia suppliers when compared to the combination of Connacht Gold, Lakeland and Donegal. However the stocking rates were similar for the two regions at 1.78 and 1.79 cows/Ha. Horan and Shalloo (2007) have shown the optimum stocking rate in the future will be between 2.7 and 2.9 cows/Ha resulting in a potentially dramatic increase in output from these farms in the future. Milk production per cow and per hectare was similar in the two regions. As stated in this paper the target milk production per hectare will be 15,000l showing huge scope for increasing output from existing land bases. The number of suppliers that stated they planned to expand was similar among the regions at 50% with slightly more stating that they planned to exit in the Glanbia region. However that may be factor of the survey timing rather than any real difference. When the total increase in output from the expanding farms is summed and the exiter's removed the stated increase was 9% and 14% for the two regions. When the potential expansion was analysed based on the current land areas removing the exiter's and producing 15,000l/Ha, there was a potential increase 70% and 60% respectively. The definite lack of a successor was similar in the two regions with the remaining farmers either definitely having a successor or were unsure on whether there would be a successor or not.

Table 7.1 Biological Results and Attitudinal Responses of a Survey of 1,400 Regionally Distributed Dairy Farmers across 4 Co-operative areas carried out during 2007.

	Glanbia	Connacht Gold/ Donegal/ Lakeland
Quota size (000, litres)	305,503	247,283
Grazing Platform Area (ha)	38.9	30.5
Stocking Rate (LU/ha)	1.78	1.79
Milking cows (No.)	64.6	52.7
Dairy specialisation (%)	0.63	0.70
Milk production (kg/cow)	4,808	5,194
(kg/ha)	8,346	9,212
Proportion expanding (%)	49	50
Proportion exiting (%)	14	9
Stated expansion	9	14.5
Potential expansion	70	60
% No successor	25	29

As indicated in the survey and based on best practice technologies, it can be anticipated that significant increases in dairy cow numbers could be accommodated on the existing land base with further increases in productivity achievable through improved animal genetics, compact calving, lengthened lactations and the provision of increased quantities of higher quality feed.

7.4 Profitable Farm Systems for the Future

Future farm systems will take the form of above average farmers leveraging debt to finance expansion and backing their ability and farming skills to generate the cash returns necessary to service the debt and deliver a satisfactory rate of return on there time and capital investment. The system must be sustainable in terms of staff, animals and the environment allowing for a quality lifestyle and providing for sufficient time-off for all staff. The system must therefore be simple and flexible allowing for increased operational scale to be achieved without requiring large amounts of additional labour. Future systems will require new industry targets for a non-quota environment with targets set with respect to profitability, productivity and labour efficiency (Table 7.2).

Table 7.2. Key Performance Indicators (KPI) for the Irish Dairy Industry.

Indicators	Current average**	Target
Milk solids per ha (kg)	660	1,250
Labour (cows/LU)	44	100
Labour cost/ha (€)	1,700	750
Profit per ha* (€)	1,030	2,500
Margin per kg milk solids (€)	1.56	2.00

*KPI's based on milk price projection of 26c/l, **based on National farm survey data (NFS, 2006)

In future, most of the costs of milk production will be directly associated with the area of land being farmed, the number of cows in the herd and the number of people employed. Therefore, consistently high cash surpluses will be generated by ensuring that high levels of milk production are achieved per hectare, per cow and per labour unit. Successful dairy farms will optimise output/ha and the margin per unit of output. Output per ha will in future be measured in kg milk solids (MS) i.e. kg of fat and protein, as that is what is required and paid for by the dairy processor with 1,250 kg MS/ha a realistic target for an efficient grass based milk production system.

A key economic principle, irrelevant of enterprise, is to optimise economic performance; one must achieve maximum profit per unit of the most limiting factor of production.

Land will become the most limiting factor of production on most farms, hence profit per ha will be a key performance indicator of a successful dairy business with a realistic target of €2,500/ha. The second major variable determining profitability on a successful dairy farm will be margin per kg of milk solid (MS) produced. This is the margin available to pay for all of the unpaid resources employed, i.e. land, labour and capital. As MS yield per ha and per cow increase, initially there will be an increase in margin per kg MS because of a dilution in fixed costs and benefits in efficiency from scale. However, as MS output per ha approaches the optimum the margin will reduce due to a reducing proportion of the diet from grazed grass. A realistic target margin per kg of MS is approximately €2.00 where MS per ha is relatively high (>1,250 kg). A higher target margin would be realistic at milk prices in excess of 26c/l or where input costs can be reduced further.

The availability of skilled labour capable of managing high performing dairy herds will also be a limitation in future and therefore dairy farms must adequately remunerate this skilled labour to compete with other sectors of the economy in sourcing and retaining staff. To achieve a high level of labour remuneration, a high output/labour unit is essential. A realistic target labour efficiency should be 22 hours per cow per year (O'Donovan *et al.*, 2007) thereby allowing one operator to manage 100 cows. The overall labour cost target should therefore be €900 per hectare with an average labour cost of €15/hr worked for both skilled and unskilled labour. The realisation of labour performance targets will depend on the simplicity of the overall system and the introduction of new technologies to reduce labour input.

7.5 The Changing Face of Farm Systems

The realisation of key performance parameters outlined above will be determined by the ability of dairy farmers to employ technologies which deliver the desired performance for the future. Prior to the introduction of milk quotas in Ireland in the mid-1980's, the optimum system of milk production was based on spring calving, stocking rate of 2.5 to 3.0 cows/ha, a concentrate input of 500 to 750 kg/cow and a nitrogen application rate of 270 to 300 kg N/ha. Five key factors will determine if key performance indicators are achieved and will provide the solutions for managing or capturing benefits of the changing production environment.

7.5.1. Stocking Rate

"No more important force exists for good or evil than the control of stocking rate in grassland farming" Dr C. P. McMeekan, New Zealand (1961)

In the previous section we have discussed the importance of milk productivity and why milk production from dairy farms will in future be limited by the land base available for the grazing dairy herd. Pasture is the main source of feed on a dairy farm therefore the hectare of pasture is a crude measure of feed supply on the farm. The choice of stocking rate remains the most important single decision which influences the pastoral dairy farms productivity. The optimum stocking rate is achieved where a balance is found between the amount of feed grown on the farm, the quality of the feed and the feed requirements of the herd. McMeekan (1956) and Rattray (1987) highlighted stocking rate as the major factor governing animal productivity from pasture due to its dominant effect on animal demand and hence pasture use. Maximum productivity of milk solids will be realised by achieving high milk solids yield per cow at relatively high stocking rates. A number of studies were carried out at Moorepark from 1978 to 1982 to measure milk production and stock carrying capacity. The results showed that increasing stocking rate from 2.5 to 2.7 cows/ha resulted in a reduction in milk yield per cow from 4,717kg to 4,611kg, but in an increase in production per hectare from 11,651kg to 12,678kg. Table 7.3 summarises a range of experiments carried out in New Zealand between 1982 and 1985 showing that as stocking rate is increased, milk solids production per cow declines but milk solids production per hectare increases. Other experiments show generally similar results with 1 additional cow/ha reducing MS by 31kg per cow and increasing MS by 122kg per hectare (Holmes and MacMillan, 1982). Consistent with these results, a review of stocking rate experiments by Delaby *et al.* (per comm., 2007) has concluded that for each additional cow per hectare increase in stocking rate, milk production per hectare will be increased by 29, 24, 19 and 14%, going from 2 cows per hectare up to 5 cows per hectare.

Table 7.3 The effect of stocking rate on pasture eaten and milk produced per cow and per hectare (where pasture growth is 16 tonnes per ha per annum).

Cows per hectare		**2.75**	**3.26**	**3.75**	**4.28**
Pasture eaten	per cow (t DM/cow/yr)	3.9	3.7	3.5	3.2
	per hectare (t DM/ha/yr)	10.8	11.9	13.0	13.9
Milk solids produced (kg/cow)		359	328	300	269
	(kg/ha)	991	1069	1128	1152
Pasture Utilisation (%)		68	77	81	87
Feed Conversion Efficiency (kg MS/t DM eaten)		92	88	86	84

(Holmes *et al.*, 2002)

Increased farm stocking rates result in increased farm profitability on Irish dairy farms in the absence of milk quotas by increasing the utilization of grass grown on the dairy farm. A recent analysis by Horan and Shalloo (2007) of Irish pasture-based systems using the production data from the 5-year strain comparison studies from Curtins Farm, Moorepark (Horan *et al.* 2005; McCarthy *et al.*, 2007) looked at the effects of increased stocking rate on milk production, feed requirement, land and labour utilisation and overall farm economic performance for a 40 hectare dairy farm in the absence of milk quotas. This analysis showed that increasing stocking rate (from 2.41LU/ha to 2.65LU/ha) increased pasture utilisation from 75% to 85%, increased milk solids output from the 40 ha (from 34,676kg to 38,191 kg) and increased overall farm profitability. When pasture growth remains static, a 10% increase in pasture utilization resulted in €6,294 (€157/ha) and €10,224 (€255/ha) additional farm profit at a milk price of 22.3 and 30.0 c/l, respectively (Table 7.4). Similar to previous studies (Penno *et al.*, 1996; McCarthy *et al.*, 2007), this analysis shows that based on various milk price projections in future years, higher stocking rate systems will be more profitable. Such systems will be characterised by their capability for low-cost high milk productivity per hectare with lesser milk production per cow.

Table 7.4 The effect of herbage production per hectare and grass utilisation on key herd parameters in a fixed land scenario using anticipated future costs and prices (Horan and Shalloo, 2007).

Herbage utilisation (%)		75			85	
Herbage Production (t DM/ha)	12	14	16	12	14	16
Utilisable herbage (t DM/ha)	9	10.5	12.0	10.2	11.9	13.6
Total hectares (ha)	40.0	40.0	40.0	40.0	40.0	40.0
Cows calving (No.)	77.2	87.3	96.9	85.4	96.2	106.4
Stocking rate (LU/ha)	2.14	2.42	2.68	2.36	2.66	2.94
Labour units (h)	1.38	1.48	1.57	1.46	1.57	1.67
Milk produced (kg)	452,794	512,044	567,764	500,486	564,153	623,653
Milk sales (kg)	438,588	495,979	549,951	484,784	546,453	604,087
Milk solids sales (kg)	30,735	34,756	38,538	33,972	38,293	42,332
Fat sales (kg)	16,123	18,232	20,216	17,821	20,088	22,207
Protein sales (kg)	14,612	16,524	18,322	16,151	18,205	20,125
Labour costs (€)	31,466	33,778	35,952	33,327	35,811	38,133
Feed costs /kg milk (c)	5.4	5.1	4.8	5.1	4.8	4.5
Total costs (€)	100,519	108,018	115,062	106,317	114,348	121,851
Milk Price at 22.3 c/litre						
Milk returns (€)	96,763	109,425	121,322	106,955	120,561	133,276
Margin per cow (€)	151	216	265	205	262	305
Margin per kg milk (c)	2.58	3.69	4.51	3.49	4.47	12.71
Total profit/farm (€)	11,683	18,871	25,629	17,469	25,192	32,406
Milk Price at 30 c/litre						
Milk returns (€)	131,458	147,654	163,721	145,304	162,680	179,837
Margin per cow (€)	603	656	705	657	702	745
Margin per kg milk (c)	10.29	11.20	12.03	11.20	11.98	12.71
Total profit/farm (€)	46,590	57,333	68,277	56,052	67,568	79,252

Increased utilization of pasture through increased stocking rates will be one avenue to increased productivity on Irish dairy farms in an expansion scenario. The maintenance of higher stocking rates requires flexible grazing management practices, feed demand management through stock movement and feed supplementation and feed supply management through the more efficient use of fertilizers and slurry to overcome the variability in pasture supply. The importance of supplementary feeds or strategic N fertilizer use to remove the constraints of pasture seasonality will depend on both the feed supply pattern, the price of supplementation and the price paid for additional milk product produced (Hodgson and Maxwell, 1988). Higher stocking rates can be facilitated on most farms by removing beef cattle, young stock and replacements from the grazing platform, reseeding pastures to increase grass growth rates, improving grassland budgeting, and making more strategic use of fertilizer and additional supplements. With the recent developments in grazing management technology on Irish dairy farms (O'Donovan *et al.*, 2000), Irish dairy farmers who have acquired grass measurement and budgeting skills are well positioned to effectively manage and capture the economic benefits of higher stocking rates.

7.5.2. Calving Date and Rate

Systems of production based on a high proportion of in situ pasture utilization are constrained by the seasonality of pasture production (Heitschmidt, 1993), thereby requiring that animal production be fit within the cycle of annual grass supply (Dillon, 1995). Within the confines of milk quotas where the total volume supplied is limited, the optimum mean calving date tends to be later thereby sacrificing overall farm milk production in order to use more cheap grazed grass to produce the fixed milk quota based on achieving a high profit per litre. While this principle is still important, the ability to increase overall production in a no quota scenario coupled with recent advances in grazing research showing that lower grass allocation levels in early lactation are sufficient to fully feed the dairy herd and achieve high animal performance (Kennedy *et al.*, 2007; McEvoy *et al.*, 2008) may have implications for the optimum calving date in a no quota scenario. In such a scenario, it will be possible to achieve greater production levels through earlier calving without reducing the proportion of grazed grass in the herd feed budget.

The influence of variation in mean calving date on the profitability of Irish pasture-based production systems in a no quota scenario. In this analysis, grazed grass constituted 70, 75, 72 and 71% of the dietary intake of cows with a mean calving date of January 31st, February 14th, March 1st and March 15th, respectively (Table 7.5). Earlier calving increases overall milk sales, milk revenues and costs of production. Feed costs are highest with January 31st calving, intermediate for March 1st and 15th calving and lowest with a mean calving date of February 14th. The highest farm profit was observed with a mean calving date of February 14th with the lowest profitability observed with a March 15th calving date. With a mean calving date of February 15th, feed costs are lowest and margin per cow and per kg milk produced is maximised. Where the mean calving date is earlier than February 14th, the gains in milk receipts are outweighed by the increased feed costs incurred through increased silage and concentrate use in the diet. Where the mean calving date is later than February 14th, the losses in production and increased feed costs incurred result in a reduction in farm profitability. The economic optimum calving date in this analysis did not change with milk price variation however the relative advantage of achieving the optimum calving date is much greater in a low milk price scenario.

Horan and Shalloo (2007) also looked at the influence of variability in calving rate on farm performance and profitability. Table 7.6 illustrates the influence of 4 alternative 42 day calving rates with the same mean calving date. As calving rate is reduced, the proportion of grazed grass in the diet reduces with little effect on total milk or milk solids production. The total costs of production and feed costs per kg milk sales both increase as calving rate is reduced. The overall economic impact on the production system is to reduce total farm income by approximately €590 per 10% reduction in calving rate due to the higher associated costs of production. However as part of these assumptions calving date remains fixed which would be extremely difficult in reality. The real affect will be a slip in calving date as well as in the spread.

Table 7.5. Key herd parameters in a fixed land base scenario using anticipated future costs and prices for four differing mean calving dates.

Mean calving date	31st January	14th February	1st March	15th March
Grass (kg DM/cow)	3,598	3,716	3,492	3,384
Grass Silage (kg DM/cow)	1,034	935	1,071	1,131
Concentrate (kg DM/cow)	477	334	322	265
Cows calving (No.)	91.4	90.9	92.2	92.9
Milk produced (kg)	546,095	533,080	517,772	503,175
Milk sales (kg)	529,292	516,355	500,814	486,090
Milk solids sales (kg)	37,113	36,184	34,977	33,859
Fat sales (kg)	19,499	18,981	18,320	17,708
Protein sales (kg)	17,614	17,203	16,657	16,151
Livestock sales (€)	18,262	18,177	18,431	18,570
Total costs (€)	115,547	110,674	111,333	110,618
Feed costs /kg milk (c)	5.5	5.0	5.2	5.30
Labour costs (€)	36,163	34,599	34,477	33,921
Milk Price at 22.3 c/litre				
Milk returns (€)	116,782	113,920	110,091	106,562
Margin per cow (€)	213	236	184	156
Margin per kg milk (c)	3.57	4.02	3.28	2.88
Total profit/farm (€)	19,497	21,423	16,966	14,514
Milk Price at 30 c/litre				
Milk returns (€)	157,580	153,719	148,583	143,844
Margin per cow (€)	663	676	604	560
Margin per kg milk (c)	11.09	11.53	10.75	10.33
Total profit/farm (€)	60,563	61,465	55,680	51,996

Table 7.6 Key herd parameters in a fixed land base scenario using anticipated future costs and prices for four differing calving patterns with the same mean calving date.

6-week Calving Rate	90	75	60	45
Grass (kg DM/cow)	3,624	3,586	3,552	3,496
Grass Silage (kg DM/cow)	983	1,007	1,030	1,067
Concentrate (kg DM/cow)	285	281	295	321
Cows calving (No.)	91.5	91.7	91.9	92.2
Milk produced (kg)	520,982	518,515	518,586	517,294
Milk sales (kg)	504,150	501,645	501,686	500,337
Milk solid sales (kg)	398	395	394	392
Fat sales (kg)	18,466	18,355	18,353	18,306
Protein sales (kg)	16,786	16,698	16,695	16,641
Livestock sales (€)	18,294	18,335	18,368	18,430
Total costs (€)	109,636	109,940	110,377	111,665
Feed costs /kg milk (c)	5.0	5.0	5.1	5.3
Labour costs (€)	34,087	34,043	34,192	34,469
Milk Price at 22.3 c/litre				
Milk returns (€)	110,988	110,361	110,338	109,994
Margin per cow (€)	212	204	197	182
Margin per kg milk (c)	3.73	3.62	3.49	3.24
Total profit/farm (€)	19,421	18,756	18,108	16,758
Milk Price at 30 c/litre				
Milk returns (€)	149,781	148,941	148,913	148,452
Margin per cow (€)	639	627	619	601
Margin per kg milk (c)	11.22	11.10	10.97	10.72
Total profit/farm (€)	58,438	57,557	56,903	55,438

The optimum calving date for the herd will depend greatly on the grass growth characteristics of the farm. Ideally, the optimum date is the earliest possible date to allow a herd lactation length of 300 days while still preventing grass silage use in the milking cow diet. In the current analysis on a Moorepark type soil, the optimum mean calving date for the herd should be February 14th with calving commencing in late January. Also evident from this analysis, late January calving is preferable to March or April calving. The optimum mean calving date for a more northerly wetter soil will be later with calving commencing mid-February. While calving date will be very much dependant on soil type and location, achieving a high calving rate of 90% calving in 42 days will be economically proficient regardless of geographic location. The average mean calving date of Irish spring-calving dairy cows is March 16th based on CMMS data (Table 7.7) with an average calving rate of 53% in 42 days (ICBF, 2006). While considerably later than the optimum as described above, these statistics show that the national mean calving date is now 8 days later than 2002. On the basis of the results obtained from Table 7. 4, it can be hypothesised that the average spring milk producer could increase total farm profitability by 18% by achieving a mid- February mean calving date.

Table 7.7 Trends in the Mean Calving Date and proportion of cows calving by month within Irish Spring-calving Dairy Herds (2002-2006).

Calving Month	2002	2004	2006
January	0.10	0.11	0.10
February	0.37	0.29	0.28
March	0.30	0.28	0.29
April	0.13	0.19	0.19
May	0.07	0.11	0.10
June	0.03	0.03	0.05
Mean Calving Date	08-Mar	14-Mar	16-Mar

Dept. Agriculture and Food CMMS Statistic Reports (2002-2006)

7.5.3. Breeding Profitable Animals for the Future

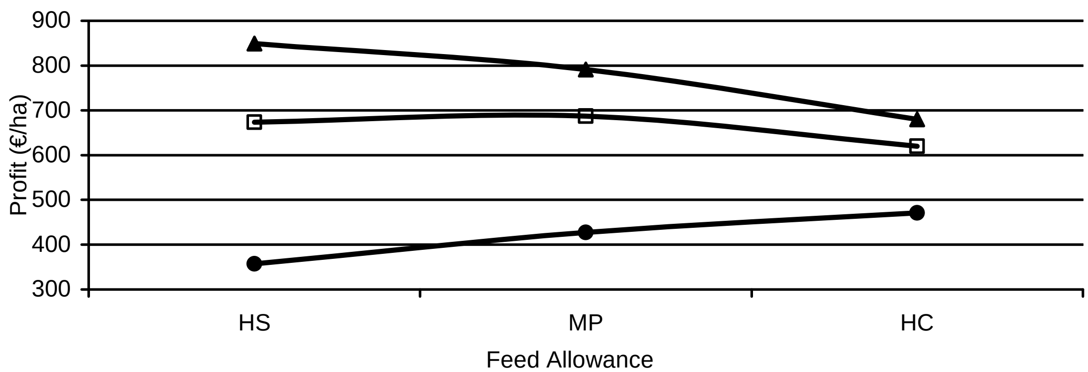
The dynamics of dairy farm expansion are far reaching. Among the factors that will limit the potential expansion of any dairy farm business, sourcing additional cows or incalf heifers will be a major limitation. Irish dairy farmers currently generate approximately 240,000 replacement heifers each year (CMMS, 2007). This level of heifer rearing is insufficient to grow the national herd once quotas are removed. Currently, only approximately 30% of incalf heifers entering Irish dairy herds originate from AI, with the vast majority sired by stock bulls of inferior genetic potential. For those producers preparing to expand, purchasing additional cows is both expensive and has associated herd health risks. On that basis, the generation of additional quality replacements from within the herd is critical to fund future expansion on Irish dairy farms.

Future farm systems will require a dairy cow of considerably higher economic value than the current average dairy cow. Compared to the current population, tomorrows herd will produce more milk solids through increased intake and energetic efficiency, achieve a 365 day calving interval and require less labour per cow to survive in a larger herd. The performance potential of higher EBI sires has been well documented in recent years. For over ten years now, research comparing alternative strains of Holstein-Friesian dairy cattle on contrasting systems of milk production based predominantly on grazed grass have been underway at Moorepark (Buckley *et al.*, 2000; Kennedy *et al.*, 2003; Horan *et al.*, 2005; McCarthy *et al.*, 2007; Coleman *et al.*, 2007). The most recently completed of these, a five-year study consisting of 585 lactations on 240 cows compared three strains of Holstein-Friesian. The three strains compared were high production North American (HP; EBI= €51), selected entirely for milk production, high durability North American (HD; EBI= €58), selected based on milk production, fertility and muscularity traits, and New Zealand (NZ; EBI= €58) selected from a seasonal calving pasture-based system.

The three feed systems compared were a high grass allowance feed system typical of spring calving herds in Ireland (MP); a higher stocking rate system (HS) and an increased concentrate supplementation system (HC). The HP cows produced the highest yield of milk, the NZ the lowest, and the HD animals were intermediate. Milk fat and protein content were higher for the NZ strain than for the HP and HD strains. The milk production response to increased concentrate supplementation (MP v. HC) was greater with both the HP and HD strains (1.10 kg of milk/kg of concentrate for HP; 1.00 kg of milk/kg of concentrate for HD) compared to the NZ strain (0.55 kg of milk/kg of concentrate). The NZ strain had an earlier calving date, higher 24 day submission rate, higher pregnancy rate to first service, higher six week in-calf rate and lower empty rate than the HP strain.

Figure 7.1 shows the profitability for the three strains across the three feed systems in a scenario where no milk quota existed and the 40ha land block was the limitation with a projected milk price of 22c/l and full labour costs included in the analysis. In this scenario, the NZ strain achieved the highest farm profit in all three feeding systems. The highest farm profit with the NZ strain was achieved in the high stocking rate feed system (€849/ha), the highest farm profit with the HD strain was achieved in the Moorepark feed system (€687/ha) while the HP strain achieved the highest farm profit in the high concentrate feed system (€471/ha). The results demonstrate how genetic selection for increased milk production (HP strain) results in reduced profitability in future years relative to selection on a combination of production and reproductive traits (HD and NZ strains).

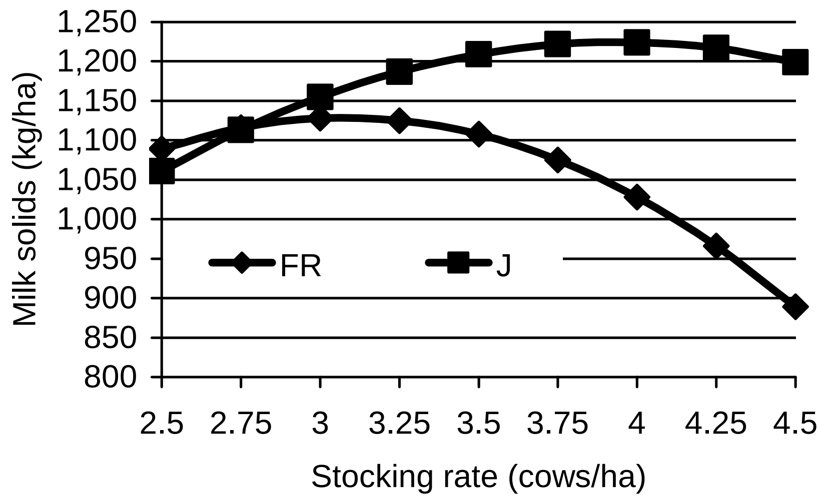
Figure 7.1. The Influence of strain of Holstein-Friesian and pasture-based feed system on farm profitability (McCarthy et al., 2007). [NZ (▲), HD (□) and HP (●)]



The efficiency of conversion of home grown feed to milk will be an important determinant of farm productivity especially considering the recent forecasts for supplementary feeds (Binfield *et al.*, 2006). In a pasture based system the amount of milk produced from a given amount of feed is a measure of the efficiency of the system with many studies observing differences in feed efficiency among breeds of dairy cows. Improvements in the genetic ability of cows to produce more milk product from existing feed resources have contributed to the improved performance of grazing dairy systems in other countries (Holmes, 1988; Bryant, 1984). Ahlborn and Bryant (1992) compared the performance of Jersey and Friesian cows at low and high stocking rates (Figure 7.2). The Jersey cows produced similar or slightly lower yields of milk solids per cow but higher yields per hectare compared to the Friesian. While initially the milk production per hectare increased with the Friesian breed, there was a reduction in milk production per hectare at the higher stocking rates, while milk production per hectare increased with increasing stocking rate with the Jersey breed. Mackle *et al.* (1996) and Oldenbroek

(1988) showed that Jersey cows were more efficient converters of grass DM into milk than the Holstein-Friesian. In a review of 11 experiments by Grainger and Goddard (2004), Jersey cows had higher DM intake per 100 kg live weight and in 8 of the experiments Jersey had higher feed conversion efficiency (g milk solids per kg of DM intake).

Figure 7.2. The influence of cow breed on milk solids production per hectare of home grown feed at various stocking rates (Ahlborn and Bryant, 1992).



7.5.4. Grass Production, Quality and Grazing Management

Animal productivity from grassland is determined by the amount of pasture grown, level of pasture utilisation and overall feed quality. Horan and Shalloo (2007) have shown that as pasture growth increased from 12 to 16 tonnes DM per hectare, the stock carrying capacity of the 40 hectares increases (from 2.25LU/ha to 2.81LU/ha) resulting in a proportional increase in milk solids produced (from 32,353kg to 40,435kg)(Table 7.4). While total costs increase due to the extra animals, feed costs per kg milk is reduced (from 5.3c/kg to 4.5c/kg) as additional grass is now grown for the same overall land rental and maintenance costs and the overall profitability of the system is increased. When pasture utilization is maintained, increasing total pasture growth increases farm profit by €3,610 (€90/ha) and €5,611 (€140/ha) where milk price is 22.3 and 30.0c/l, respectively. Similarly, as pasture quality increased from 75 to 87% organic matter digestibility (OMD), the stock carrying capacity of the 40 hectares increased resulting in a proportional increase in milk solids sales (Table 7.8). While total costs increase due to the extra animals, feed costs per kg milk are reduced. When pasture utilization is maintained, each 1% increase in OMD results in an increase in overall farm profit by €759 (€19/ha) and €1,229 (€31/ha) where milk price is 22.3 and 30.0c/l, respectively.

Table 7.8. The effect of herbage Organic Matter Digestibility (OMD) on key herd parameters in a fixed land scenario using anticipated future costs and prices.

Grass quality (% OMD)	**75**	**78**	**81**	**84**	**87**
Total hectares (ha)	40.0	40.0	40.0	40.0	40.0
Cows calving (No.)	78.7	82.0	85.3	88.5	91.6
Stocking rate(LU/ha)	1.18	2.27	2.36	2.45	2.53
Labour units (No.)	1.39	1.42	1.46	1.49	1.52
Milk produced (kg)	461,069	480,958	500,266	519,018	537,238
Milk sales (kg)	446,604	465,868	484,571	502,735	520,383
Milk solids sales (kg)	31,296	32,647	33,957	35,230	36,467
Fat sales (kg)	16,417	17,126	17,813	18,481	19,130
Protein sales (kg)	14,879	15,521	16,144	16,749	17,337
Feed costs /kg milk (c)	5.30	5.20	5.10	5.00	4.90
Labour costs (€)	31,789	32,565	33,318	34,050	34,761
Total costs (€)	101,355	104,081	106,295	108,895	110,995
Milk Price at 22.3 c/litre					
Milk returns (€)	98,532	102,782	106,908	110,915	114,809
Margin per cow (€)	161	184	204	223	239
Margin per kg milk (c)	2.75	3.14	3.49	3.80	4.08
Total profit/farm (€)	12,687	15,100	17,443	19,717	21,927
Milk Price at 30 c/litre					
Milk returns (€)	132,955	138,690	144,257	149,665	154,919
Margin per cow (€)	602	624	645	663	680
Margin per kg milk (c)	10.26	10.65	11.00	11.31	11.59
Total profit/farm (€)	47,320	51,227	55,020	58,703	62,282

Pasture growth will be increased on dairy farms by rejuvenating old swards through reseeding and ensuring that soil fertility is adequate for maximum plant growth. Grass breeding has increased DM yield by 0.5% per year in the Netherlands from 1965 to

1990 (Van Wijk and Reheul, 1991). Gately (1984) compared an early perennial (Cropper) with a late perennial ryegrass (Vigour) for milk production at two stocking rates. At a low stocking rate, the improved digestibility of the Vigour gave 8.8% more milk yield than Cropper. However, at the higher stocking rates, Cropper gave 6.6% more milk than Vigour, because of the greater pasture production in early spring at the time of peak milk yield.

Pasture quality can be improved through grazing management practice and the selection of higher quality grass varieties. During mid-season, Hurley *et al.* (2007) observed variability of up to 3 units in OMD between perennial ryegrass varieties of similar heading date. Thomson (1985) has shown that lax grazing reduces subsequent animal production performance, through a decline in feed quality. Tighter spring grazing has been shown to increase the milk production of dairy cows (Holmes and Hoogendoorn, 1983; Hoogendoorn *et al.,* 1985) in the following summer. Stakelum and Dillon, (1990) and Kennedy *et al.*, (2006) have shown under Irish conditions that tightly grazed pastures in spring/early summer produced swards with a higher proportion of green leaf and lower proportion of grass stem and dead material compared to swards with low grazing pressure. Increasing post grazing sward surface height above 5 to 6 cm has been shown to result in a deterioration of sward quality in mid and late grazing season (Stakelum and Dillon, 1990).

7.5.5. The Role of Supplementation in Future Systems

The ability to avail of the increased profitability of pasture-based systems may be curtailed by land costs (both rental and purchase). Access to land at economically feasible prices is crucial to the future success of pasture based dairy systems. Increased feed supplementation may be an alternative expansion strategy for some producers where land availability is limited and therefore the development of efficient profitable pasture-based systems incorporating greater proportions of supplementary feeds also merits consideration. The use of imported supplementary feeds on many farms has introduced greater flexibility into the management of feeding, as pasture deficits caused by slower than expected growth can be filled by these other feeds thus meeting the requirements of both animals and pastures.

Table 7.9 illustrates the influence of increased concentrate supplementation on farm profitability at various concentrate prices and levels of milk production response where stocking rate is not increased in comparison to a base system at a similar concentrate purchase price. When stocking rate is held constant, increased concentrate supplementation relative to the base system results in reduced grass DM intake, increased milk production per cow and increased feed costs. At a low milk price (22.3c/l), increased concentrate supplementation results in a reduction in farm profit at concentrate prices of €250 per tonne or greater, regardless of the level of milk production response to concentrate supplementation (between 0.6 and 1 kg milk per kg concentrate). At a high milk price (30 c/l), increased concentrate supplementation relative to the base system results in an overall increase in farm profitability only where a response to concentrate of 1kg additional milk per kg additional concentrate fed is achieved and concentrate is purchased at €250 per tonne. Where a response of 0.6 to 0.8 kg milk per kg additional concentrate is achieved or at a concentrate purchase price of €300 per tonne, increased concentrate supplementation will reduce overall farm profitability.

Table 7.9 The effect of milk production response rate and concentrate price on the key herd parameters and farm profitability using anticipated future costs and milk prices where stocking does not increase.

Concentrate costs €/tonne	€250				€300			
Response to concentrate	Base	0.60	0.80	1.00	Base	0.60	0.80	1.00
Grass kg DM/ Cow	3,716	3,292	3,357	3,422	3,716	3,292	3,357	3,422
Grass Silage kg DM/cow	935	789	792	795	935	789	792	795
Concentrate kg DM/cow	334	1,240	1,240	1,240	334	1,240	1,240	1,240
Total hectares (ha)	40	40	40	40	40	40	40	40
Milk yield Kg/cow	5,862	6,340	6,500	6,659	5,862	6,340	6,500	6,659
# Cows calving (no.)	90.9	90.9	90.9	90.9	90.9	90.9	90.9	90.9
Stocking rate(LU/ha)	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51
Herbage used Kg DM/Ha	11,056	9,589	9,765	9,943	11,056	9,589	9,765	9,943
Labour units (h)	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51
Milk produced (kg)	533,080	576,323	590,805	605,286	533,080	576,323	590,805	605,286
Milk sales (kg)	516,355	559,605	574,086	588,568	516,355	559,605	574,086	588,568
Fat sales (kg)	18,981	20,573	21,105	21,638	18,981	20,573	21,105	21,638
Protein sales (kg)	17,203	18,640	19,122	19,603	17,203	18,640	19,122	19,603
Labour costs (€)	34,599	34,591	34,591	34,591	34,599	34,591	34,591	34,591
Feed costs /kg milk (c)	5.0	7.8	7.5	7.3	5.3	8.5	8.3	8.1
Total costs (€)	110,674	129,149	128,333	128,642	112,319	133,438	133,739	133,500
Milk Price 22.3 c/Lt								
Milk returns (€)	113,920	123,449	126,639	129,829	113,920	123,449	126,639	129,829
Margin per cow (€)	236	137	178	213	218	87	122	156
Margin per kg milk (c)	4.02	2.16	2.74	3.20	3.71	1.37	1.87	2.35
Total profit/farm (€)	21,423	12,470	16,205	19,357	19,797	7,917	11,069	14,221
Milk Price 30 c/LT								
Milk returns (€)	153,720	166,578	170,883	175,188	153,720	166,578	170,883	175,188
Margin per cow (€)	676	615	668	715	658	564	611	659
Margin per kg milk (c)	11.53	9.69	10.28	10.74	11.23	8.90	9.41	9.89
Total profit/farm (€)	61,465	55,862	60,720	64,994	59,839	51,310	55,584	59,858

Table 7.10 illustrates the influence of increased concentrate supplementation on farm profitability at various concentrate prices and levels of milk production response where

stocking rate is increased in comparison to a base system at a similar concentrate purchase price. In this scenario, increased concentrate supplementation results in reduced grass DM intake per cow, increased milk production per cow, increased cow numbers on the 40 ha (i.e. an increase in stocking rate), increased labour input and costs, increased feed costs and increased total costs of production. At a low milk price (22.3 c/l), additional concentrate supplementation will only result in increased farm profitability where concentrate is purchased at €250 per tonne and a milk production response of greater than 0.8kg of additional milk is realised per kg additional concentrate fed above the base level. At a milk production response of 0.6kg/kg or where concentrate purchase price is €300 per tonne, increased concentrate supplementation will result in a reduction in farm profitability. Where milk price of 30c/l is achieved, additional concentrate supplementation results in increased farm profitability for all milk production responses and for concentrate purchase prices of €250 and €300 per tonne.

Systems of production based on supplementation at pasture must be clearly defined to ensure that supplementation is efficient and does not lead to a reduction in pasture utilization on the dairy farm. It is envisaged that the cost of external supplements will continue to increase due mainly to increases in contractor charges associated with inflation in labour, energy and machinery costs. The profitability of supplement inclusion will be determined by the milk to concentrate price ratio and the level of additional milk production achieved in response to supplementation. If the market value of the additional milk achieved outweighs the costs of supplement inclusion and pasture utilisation is not compromised, higher supplementation levels may yield greater farm profit. However, if milk price reduces, the economic feasibility of concentrate use within the dairy feed budget declines as the marginal benefit of increased milk output is outweighed by the cost of the additional supplementation.

Table 7.10. The effect of milk production response rate and concentrate price on the key herd parameters using anticipated future costs and milk prices where stocking rate increases.

Concentrate costs €/tonne	**€250**				**€300**			
Response to concentrate	Base	0.60	0.80	1.00	Base	0.60	0.80	1.00
Grass kg DM/ Cow	3,716	3,292	3,357	3,422	3,716	3,292	3,357	3,422
Grass Silage kg DM/cow	935	1,240	792	795	935	1,240	792	795
Concentrate kg DM/cow	334	789	1,240	1,240	334	789	1,240	1,240
Total hectares (ha)	40	40	40	40	40	40	40	40
Milk yield per cow (Kg)	5,862	6,340	6,500	6,659	5,862	6,340	6,500	6,659
Cows calving (No.)	90.9	101.8	100.3	98.9	90.9	101.8	100.3	98.9
Stocking rate(LU/ha)	2.51	2.81	2.77	2.73	2.51	2.81	2.77	2.73
Labour units (h)	1.51	1.62	1.61	1.59	1.51	1.62	1.61	1.59
Milk produced (kg)	533,080	645,159	651,937	658,478	533,080	645,159	651,937	658,478
Milk sales (kg)	516,355	626,444	633,488	640,291	516,355	626,444	633,488	640,291
Fat sales (kg)	18,981	23,030	23,289	23,540	18,981	23,030	23,289	23,540
Protein sales (kg)	17,203	20,867	21,100	21,326	17,203	20,867	21,100	21,326
Labour costs (€)	34,599	37,074	36,742	36,418	34,599	37,074	36,742	36,418
Feed costs /kg milk (c)	5.0	7.5	7.30	7.10	5.3	8.4	8.10	8.00
Total costs (€)	110,674	139,114	137,435	135,844	112,319	145,289	142,804	141,431
Milk Price at 22.3 c/litre								
Milk returns (€)	113,920	138,193	139,743	141,239	113,920	138,193	139,743	141,239
Margin per cow (€)	236	188	223	251	218	130	166	195
Margin per kg milk (c)	4.02	2.96	3.43	3.78	3.71	2.05	2.56	2.93
Total profit/farm (€)	21,423	19,124	22,357	24,859	19,797	13,244	16,689	19,272
Milk Price at 30 c/litre								
Milk returns (€)	153,720	186,473	188,564	190,584	153,720	186,473	139,743	141,239
Margin per cow (€)	676	665	713	753	658	608	656	697
Margin per kg milk (c)	11.53	10.49	10.96	11.31	11.23	9.58	10.09	10.47
Total profit/farm (€)	61,465	67,699	71,478	74,506	59,839	61,819	65,810	68,919

Ultimately, future farm systems must be based on achieving consistently high profit margins regardless of the wider financial climate, and therefore within a volatile milk price environment, it is our recommendation from this analysis that producers should initially focus on achieving high performance from high margin low cost systems based on the maximum utilization of grazed grass and limited use of alternative feeds. Only when this base system is developed and managed to a consistently high standard should greater supplementation be considered in a favourable economic climate.

7.6 Financial Implications of High Performance Technology on Surveyed Farms

Based on survey data outlined in table 7.1, it is possible to estimate the financial implications of technical improvement on Irish dairy farms. Through the combination of the removal of non-dairy stock, increasing the overall stocking rate on the grazing platform to 2.8cows/Ha, achieving the optimum calving date, breeding better quality animals and better feed management (grass and purchased supplement), it is estimated that the profitability of the surveyed farms could increase by €1,800 per ha (Table 7. 11). This increase in profit could be further enhanced by continued genetic improvement of the herd, superior grazing management and making more strategic use of supplements.

Table 7.11. Biological and Financial Implications* of Technological Improvement on Surveyed dairy farms.

	Survey Average	Potential	Profit Differential (€)/Ha
Milk yield (kg/ha)	8,684	15,000	1,000
Mean calving date	March 17^{th}	Feb 15^{th}	250
Breeding (Herd EBI; €)	42	80	400
Feed costs (c/kg DM grown)	8	5.5	300

* based on milk price of 30c/l

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Appendix 1: Details of Adjustment Costs

The first stage of expansion up to the threshold level X_i involves increasing cow numbers by disposing of Non-Dairy livestock (*ND*) – typically beef cattle.[6] To allow for replacements each non-dairy livestock unit is equal to one dairy cow less the farm's herd replacement rate (RP_i). The quantity of extra milk then depends on the yield record on farm *i* in period *t* ($Yield_{it}$). Hence, the extent of this expansion differs with each farmer's resource base and technical efficiency; this is expressed as follows;

$$X_i = 0.5ND_i(1 - RP_i) \times (Yield_{it}) \quad (1)$$

The incremental adjustment cost per litre (C_{ix}) for farm *i* associated with this stage of expansion are derived from:

- Replacing a beef livestock unit with dairy results in a net increase in labour of 23 hours per cow. The cost of extra labour ($Wage_t$) is assumed to be €12 per hour, increasing over subsequent time periods according to projected wage rate inflation.
- Infrastructure costs in the first expansion stage (*InfraX*) comprise the conversion of existing non-dairy accommodation (estimated cost of €300 per cow) plus upgrading of dairy facilities (estimated cost of €406 per cow).
- Infrastructure costs are fully written-down over a 10-year period on a straight-line basis. The investment is financed using a 10-year term loan at an interest rate of 6 per cent. Interest in each year for the amortized loan is computed by applying the appropriate period compound interest factor ($IntFac_t$) to the sum invested.
- The cost of retaining additional replacement heifers.
- The foregone profit per livestock unit on Non-Dairy livestock (*NDProf*), excluding the decoupled payment, is estimated from NFS data. In 2006, the average profit per beef livestock unit was €103.

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[6] As data on land fragmentation is not available, it is assumed that only half of the non-dairy stock can be replaced with dairy cows.

Thus the adjustment cost per litre of quota investment in this stage would be:

$$C_{ix} = \frac{23(Wage_t) + (0.1 + IntFac_t)(InfraX) + NDprof_{it}(1 + RP_i)}{(Yield_{it})} \qquad (2)$$

The second stage of expansion which occurs after threshold X_i is more costly as it involves acquiring additional land and increasing overall livestock numbers. The costs are as follows;

- Land rental costs are estimated to be €268 per year hectare (*Rent*). The additional land required is dependent on the stocking rate of the farm (SR_i).
- Full labour costs are assumed in this expansion stage involving annual input of 35 hours per cow. The wage rate ($Wage_t$) is €12 per hour in the first time period and increases in subsequent time periods.
- Infrastructure costs (*InfraY*) in the second stage involve expansion of milking facilities and construction of new housing at a combined cost of €1,633 per additional cow.
- Infrastructure costs are fully written-down over a 20-year period on a straight-line basis. The investment is financed using a 20-year term loan at an interest rate of 6 per cent. Interest in each year for the amortized loan is computed by applying the appropriate period compound interest factor ($IntFac_t$) to the sum invested.
- Additional cows are purchased for an average price of €1,320 (*CowCost*) and the interest rate (Int_t) on capital invested in the extra cows is assumed to be 6 per cent.

Therefore, the incremental adjustment cost per litre of quota investment in this stage can be written as:

$$C_{iy} = \frac{\left(Rent / SR_i \right) + 35(Wage_t) + (0.1 + IntFac_t)(InfraY) + (1 + Int_t)(CowCost)}{(Yield_{it})} \qquad (3)$$