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# Modelling the Impact of Decoupling on Structural Change in the Farming Sector: integrating econometric and optimisation models

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# Modelling the Impact of Decoupling on Structural Change in the Farming Sector: integrating econometric and optimisation models

**Abstract**

*This paper analyses implications of the 2003 Mid Term Review of the CAP, particularly decoupling of direct payments from production, for Irish farming. Using the Irish FADN data base, an integrated modelling approach involving optimisation models and econometric estimation has been developed to analyse the continued economic viability and the changing structure of farming. Farm level adjustments in response to policy reform are modelled to facilitate the estimation of the effect of a policy on structural aspects of Irish farming such as the number of farms, the proportion of full and part-time farms, the number of dairy farms, the volume of production, the level of farm income and the viability of farming. The first step in this approach is to develop, and solve annually, a profit maximising linear programming model for each farm included in the FADN data set. These linear programming models use results generated by three exogenously estimated models. These results are of three types: (i) estimates of the effect of policy on the rate of entry and exit from farming and thus farm numbers; (ii) more 'positive' projections of the effect of policy on the allocation of farm labour; and, (iii) projections of reallocation of exiting farmers' land and milk quota, within the sector and quantitative estimates of how policy changes might affect that reallocation. The use of the proposed modelling approach suggests that farm numbers will decline over the next five years and, the rate of decline will accelerate further after decoupling relative to a continuation of Agenda 2000 policies. Decoupling is likely to result in a more positive economic outlook for beef farming with an increase in the number of economically viable beef farms. The number of beef farmers relying on income from outside the farming sector will however increase. Dairy farmers will face a price cost squeeze and that the pace of structural change in this sector of farming will accelerate due to decoupling. Despite an increased availability of milk quota for farmers remaining in business, the number of economically viable dairy farming businesses is set to decline.*

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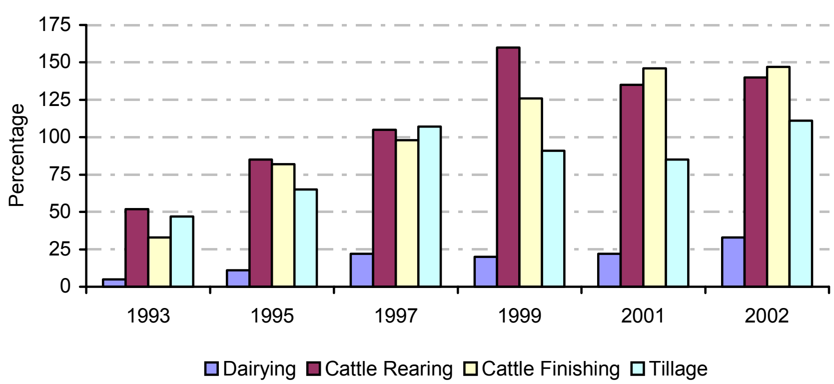
**Introduction**

The Mid Term Review (MTR) of the Common Agricultural Policy (CAP) has allowed for the decoupling of all direct payments from production from 2005 onwards; until then, most direct payments were coupled to production, requiring farmers to produce specific products in order to claim support. After decoupling, farmers will receive a payment regardless of production as long as their farm land is maintained in accordance with good agricultural practices. Direct payments to farmers have been an integral part of the CAP since the 1992 Mac Sharry reforms. Throughout the 1990s, market prices for farm produce have declined generally in line with policy while costs of production have continued to increase. Meanwhile, direct payments increased in value, increasing farmers' reliance on this source of income. Furthermore, farmers adapted farming practices to maximise their receipt of direct payments, leading to the culture of 'farming the subsidy'. By 1997, on cattle and tillage farms in Ireland 100 per cent of family farm income was derived from direct payments, meaning that on average the market-based revenue was insufficient to cover total costs. Farmers engaged in production only to receive the payments, see Figure 1.

**Figure 1: Direct Payments as a Percentage of Family Farm Income on Irish farms**




*Source: Irish National Farm Survey, Teagasc.*

The decoupling of direct payments is expected to have major ramifications for aggregate agricultural production, farm practices and the structure of farming in Ireland. It will significantly reduce the actual 'coupled' return to production; and, in some cases, the return to coupled production will be negative. This paper presents a modelling approach developed to assess the changes that are likely to be engendered by decoupling, in terms of the implications for the economic viability and the structure of farming in Ireland. The paper begins by providing some background to the economics of decoupled payments and the challenges of modelling such policy instruments. Following on from this, the proposed modelling approach is outlined and described. The results of the modelling exercise are presented and the paper concludes with some recommendations for future research.

**The Challenge of Modelling Decoupling and its Relationship with Structural Change**

The difficulties of expanding the EU within the constraints of a limited agricultural budget, the desire to make agriculture more market oriented and, the perceived need to formulate policies that are defensible within the current WTO processes which have lead to pressure for reform of the direct payment system in place for the EU farmers. It was in response to these pressures that the Luxembourg Agreement was ratified in June 2003, making it possible to decouple all (or some) direct payments from production.[1] In Ireland, all payments are decoupled from production from January 2005. A decoupled payment is based on the number of premiums received in a historical reference period, paid in the form of a per hectare Single Farm Payment (SFP) the land under farming during the reference period.

Economic theory suggests that if coupled subsidies are replaced with decoupled payments, then production falls to a level that would exist without any subsidies. If such a situation transpires, then production on farms making a market-based loss should fall substantially post decoupling unless

[1] For further details on the partial decoupling options included in the Luxembourg Agreement see European Commission (2003).

significant cost management or efficiency gains can be achieved. The production effects of decoupled payments however are still somewhat of an enigma. Burfisher and Hopkins (2003) have reviewed research on the topic to show that even fully decoupled payments have a 'production inducing effect' as they affect farmers' exposure to economic risk, their access to capital and their future expectations. Whilst direct payments may be decoupled from production there may still be an 'incentive effect', which can occur if some residual production or resource use is still required to qualify for the decoupled payment (Swinbank 2004). Although production is not necessary after the MTR, the direct payment remains tied to land. Even if payments were not to be linked to production at all, supply will not be so price sensitive so as to immediately fall to the free trade levels, which is especially the case for multi-period activities such as livestock.

With or without a link to production, payment is a source of revenue for the farm household and thus it may indirectly affect production decisions through what is referred to as a 'wealth effect'. Hennessy (1998) and Sckokai & Moro (2002) have explored the interaction between decoupled payments, farmers' risk preferences and production decisions. They conclude that if farmers' aversion to risk declines as income increases, then an increase in wealth can induce them to take riskier production decisions; thus, output increases compared to the situation when no decoupled payment is made. Decoupled payments also relax the household's capital constraint, lowering the cost of capital to the household. According to Andersson (2004) the resulting effect is that farm investment is likely to be greater after decoupling than in the absence of such payments. Revell and Oglethorpe (2003) have recently explored the expectations effect, claiming that producers may adopt a 'safety first' strategy and make only minimal changes to production plans in case future payments are reassessed and again related to production or an agricultural activity. It is clear then that even decoupled payments can influence production decisions. This paper explores some of these issues empirically. Whilst farmers' risk preferences or investment plans are not modelled explicitly, the effect of decoupling on production decisions, entry and exit decisions and the pace of structural change in farming is explored.

Despite the long-standing interest in structural change in farming, modelling such change still remains notoriously difficult (Garvey and Steele 1999). The processes of structural change play a powerful role in the analysis of competitive industries in standard microeconomic text books, but as noted by Gale (2002), there has been relatively little empirical study of the process in farming. The available empirical models of structural change in agriculture mostly focus on the aggregate by examining changes in the total number of farms using time-series econometric models or changes in the numbers in various sub-sections of the population using, for example, Markov Chain models. Such aggregate modelling approaches are often criticised for overlooking the micro dynamics of change (Jackson-Smith 1999). Furthermore, such models do not lend themselves conveniently to policy analysis as it is difficult to quantify the relationship between policy instruments and changes in farm numbers.

The Markov Chain is probably the most frequently used model for analysing structural change. Recently, non-stationary Markov Chain models have been used to project changes in the structure of farming in response to exogenous shocks, see (Zepeda 1995; Karantininis 2001; and. Jongeneel 2002). Theoretically, the non-stationary Markov Chain model would analyse the effect of a policy reform and likewise, regression techniques could be used to estimate the effect of the new policy on the probability of farms moving from one structural state to another. There are however two main reasons why a Markov Chain model is not appropriate for the research questions addressed in this paper. First, the limited details available in the Irish macro data it is not possible to develop a model that allows movement between all states of structural change; that is, a matrix of transition probabilities for all n*n cells cannot be estimated. It is therefore necessary to use a Krenz-modified Markov Chain, which assumes that an identifiable pattern of structural change is evident; for example, farms getting bigger, only small farms exiting and entry only through one size class. This assumption is not tenable for Ireland, as exits from farming occur from all sizes and systems and farms of all sizes and systems choose to transfer into part-time farming. Furthermore, given the major policy reform under investigation, new structural states may evolve, for example the existence of the "sofa farmer", and the Krenz-modified Markov Chain model cannot predict unprecedented structural states.[2]

The second problem in using non-stationary Markov Chains is the estimation of the transition probabilities; the model assumes that the historical relationships between the various exogenous variables and the transition probabilities remain constant into the future. This assumption is not sustainable in analysing the effect of a change in intervention prices or export subsidies, that is the policy instruments are the same and there is simply a marginal adjustment to their value. Decoupling is an unprecedented change to policy and hence the coefficients estimated from regression analysis on data from an Agenda 2000 type policy regime would not be appropriate for decoupling.[3] Furthermore, with decoupling new policy instruments emerge, most notably the SFP. To analyse the effect of the SFP in a non-stationary model, it is necessary to identify a proxy for the SFP. Identification of a suitable proxy variable, that is a source of revenue to the household that is linked to land but not to production, is problematic. Given these difficulties, it was decided to move away from a Markov Chain type methodology and instead to develop a farm level model of structural change.

**Methodology**

In this paper the FAPRI-Ireland model is adapted to estimate the effect of decoupling on the pace of structural change in Irish farming. The FAPRI-Ireland Partnership consists of a partial equilibrium model of Irish agriculture, which is linked to the FAPRI EU GOLD model, and a set of farm level models. At the aggregate level, a set of individual econometrically estimated commodity models are linked and solve simultaneously under different policy scenarios. The farm level modelling system is

[2] A sofa farmer is one who uses the farm land only to claim the decoupled payment but not to produce any tangible agricultural output.
[3] This criticism is due to Lucas (1976) who, in his seminal paper, argued that empirical models estimated under a specific policy regime are not applicable for economic analysis under another policy regime because the parameters of an estimated model embody the policy under which the data were generated.

comprised of a number of representative farms that are modelled using multi-period profit maximising linear programming (LP) models. This modelling system however, does not account for how policy may affect the pace of structural change in faming or the reallocation of resources that may occur as a result of a policy change. In this paper the FAPRI-Ireland farm level models are adapted to estimate the effect of decoupling on structural change in farming.

The proposed methodology involves integrating econometric and optimisation models. A profit maximising LP framework is retained to simulate production decisions. The advantage of LP is it does not rely on time-series data and it does not extrapolate future relationships from historical ones, and therefore it can go beyond the realm of past observations and analyse unprecedented changes. The disadvantages of using LP however are its normative nature and its limited scope to project population change. To overcome these weaknesses, the LP model is supplemented with a number of exogenously estimated models of farmer behaviour that can quantify the effects of non-pecuniary factors on farmers' decision-making. Three exogenous models were estimated: first, entry to and exit from farming; second, labour allocation; and third, land and milk quota distribution. The first model simulates the Irish farming population. The second model estimates the number of part-time farmers and the amount of farm labour to provide the right hand side parameters for the labour constraint in the LP models. The third model simulated the allocation of land and milk quota; again, to provide the right hand side parameters for the land and quota constraints in the LP models.

**Modelling Entry and Exit Decisions**

Many studies of entry and exit in the farming sector have concluded that age related variables are the most significant factors (Gale 1999 and Glauben et al 2003). Gale noted that there is a common perception that farm numbers are in decline due to accelerated exits. His research on farm numbers in the US in the 1950s and 1960s, however, shows the decline is mostly due to a substantial drop in new entrants concurrent with a steady rate of retirement. An age cohort analysis of the Irish data reveals that farm numbers in Ireland are in net decline as older farmers leaving the sector exceed the young new entrants. Hence entry and exit from farming are modelled in the context of succession and retirement decisions. Several empirical models of retirement were developed, including early retirement scheme and heir identification models. Due to the lack of verifiable empirical data and in the absence of a statistically significant model, it was necessary to assume that the retirement process is independent of the agricultural policy environment and that retirement occurs on average at 70 years of age, as suggested by previous qualitative research (Gasson, Errington and Trantrer 1998). Better empirical data are available on the succession decisions and it is therefore possible to quantify the factors affecting a young person's decision to enter farming.

The decision to enter farming is modelled in the context of the nominated farm heir's occupational choice between farm and non-farm work (Hennessy and Rehman 2006). Drawing on the seminal contribution by Schmidt and Strauss (1975), a model of occupational choice is developed. Theoretically, an individual chooses his/her eventual occupation by comparing the discounted utilities derived from all alternative occupations over the entire expected life-span of a career and, then chooses the occupation that maximises life-time utility (Barkley 1990). The individual *i* is assumed to have a subjective evaluation of each occupation type and to choose the occupation with the highest utility index. Thus for the individual *i* faced with *j* choices, the utility of choice *j* is

$$U_{ij} = \alpha + \beta' x_{ij} + \varepsilon_{ij} \qquad (1)$$

where $\beta' x_{ij}$ is a function of the observed attributes of the alternative, the occupational choice and the observed characteristics of the decision-maker and $\varepsilon_{ij}$, the random component, represents the unobserved attributes of the occupations and the decision-maker. If the individual makes the choice *j = 1* then $U_{ij}$ is maximised from among the *j* utilities. The empirical model is driven by the probability that choice *j* is made, that is:

$$\text{Prob}(U_{ij} > U_{ik}) \qquad \forall\, k \neq j \qquad (2)$$

The above probability is estimated using the multinomial logit model (MNL). In the MNL $x_{ij}$ denotes the vector of variables that influence the utility associated with each occupational choice *j* as perceived by each individual heir *i*. The probability that individual *i* will choose occupation *j* is

$$\text{Prob}(i \text{ chooses } j) = \frac{\exp(\beta' x_{ij})}{\sum_{k=1}^{m} \exp(\beta' x_{ik})} \qquad (3)$$

where *m* equals the number of occupations in the choice set. It is assumed that the nominated farm heir is faced with three choices; full-time farming, a non-farming occupation and part-time farming; that is, combining both farm and non-farm work.[4]

Using data collected by the Irish National Farm Survey (NFS) on farmers' succession plans and their heirs' occupational choices the above MNL model can be estimated. Farmers participating in the survey were questioned about their succession plans and their nominated farm heirs' future plans. Farmers were asked first if they had nominated an heir and subsequently about what they expected their heir to do in future, i.e. continue the farm or not.[5] The nominated heirs' occupational choice is represented by the categorical variable CHOICE. The empirical data suggest that part-time farming is the most common occupational choice as reported by 48 per cent of respondents, whereas just 21 percent of farms are likely to continue on a full-time basis. Using the MNL framework, the farm and personal characteristics that are hypothesised to affect the succession can be tested empirically. Table 1 presents the variables included in the MNL model.

The results of the MNL model show that an heir's educational achievements influence all occupational choices significantly (appendix 1). Interpreting the effect of education on the

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[4] Whilst there may be many non-farming occupations, they have been combined to one occupational category here as our interest is specifically in the probability of entering farming.

[5] The data on the nominated farm heirs' occupational choices suffers from generational bias in that it reflects the current generations' opinions of what their heirs will do rather than the heirs' actions or plans. However, it is the only such data available for this study.

occupational choice is problematic. The third level education is a self-selecting process and thus participation in education may not vary autonomously from other factors that influence the occupational decision; that is, the occupational and educational decisions are joint decisions and should be modelled thus by using a bivariate probit specification. This specification is a simultaneous equation model which tests and controls for the endogeneity of the two choices that are related. The results of this bivariate probit model (appendix 1) suggest that the educational and succession decisions are indeed determined jointly, showing that heirs with third level education are significantly less likely to enter full-time farming and that education participation is negatively influenced by farm income. Thus, if decoupling results in a decrease in farm incomes then the probability of farm heirs entering third level education will increase, thereby reducing the probability of their participation in full-time farming.

**Table 1: Independent variables for the occupational choice model**

| Variable | Description | Unit | Mean | Std Dev |
|---|---|---|---|---|
| FFI | Family Farm Income | €'000 | 22.876 | 22.8 |
| FFI2 | Family Farm Income Squared | €0'000 | 1.04e+09 | 1.95e+09 |
| UAA | Utilised Agricultural Area | Acres* | 53.3 | 54.9 |
| UAA2 | Area Squared | Acres | 5844 | 27157 |
| LUS | Livestock Units | Unit | 73.8 | 60.3 |
| LUS2 | Livestock Units Squared | Unit | 9081.1 | 17416.76 |
| FJOB | Dummy=1 if current farm operator has an off farm job | Yes/No | 0.23 | 0.42 |
| SJOB | Dummy=1 if operator's spouse has an off farm job | Yes/No | 0.30 | 0.46 |
| DAIRY | Dairy=1 if farm is in dairying | Yes/No | 0.42 | 0.49 |
| HED3 | Dummy=1 if heir has third level education | Yes/No | 0.22 | 0.41 |

*N=514, * An acre equals 0.404 of a hectare.*

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**Modelling Labour Allocation Decisions**

It is hypothesised that decoupling will lead to a significant decline in the return to farm labour resulting in a shift of labour out of agriculture. The allocation of labour cannot be modelled effectively in a profit maximising LP model as the model will reallocate labour to the most profitable activity regardless of preferences, the stickiness of labour and the hidden costs associated with reallocating labour. The allocation of labour is modelled exogenously so as to quantify the effect of decoupling on (i) the number of part-time farmers and (ii) the amount of labour available for farm work.

Theoretically, farmers' labour allocation can be explained using the agricultural household model (Singh, Squire and Strauss 1986). The essence of the model is that farmers maximise a utility function which is a function of consumption and leisure, subject to time and budget constraints. An individual optimises his/her utility by choosing those levels of hours of farm labour, off-farm labour and leisure so as to equate the respective marginal utilities of time spent on each alternative use. Consumption and leisure are restricted by a budget constraint. Income is derived from farm profit depending upon the amount of labour allocated to farm work, from off-farm wages obtained from the amount of labour allocated to such work and also, from non-labour income, that is, income generated without any labour input, for example, investments. The shift from coupled to decoupled subsidies is likely to affect labour allocation within the household too. Coupled subsidies are attached to production and are, therefore, equivalent to an increase in the marginal value product of farm labour. The decoupled subsidy is not attached to production but it is nonetheless a source of revenue for the household and is thus 'non-labour' income. It follows then that decoupling is likely to affect the relative return to farm work in two conflicting ways. First, the return to farm labour will decline significantly and, other things being equal, farmers will substitute off-farm employment for farm labour; that is the substitution effect. An increase in non-labour income however relaxes the budget constraint, allowing the farmer to work less and maintain consumption; the so called wealth effect.

The above theoretical analysis can be tested empirically using econometric labour participation and labour supply models (Hennessy and Rehman 2005). The participation model is a binary probit which estimates the effect of a vector of exogenous variables on the farmers' probability of participation in the off-farm labour market. The labour supply model is an OLS (ordinary least squares) model where the dependent variable is the number of hours a farmer devotes to off-farm employment. The dependent variable is incidentally truncated, as for some farmers who do not work off-farm the number of hours recorded is zero; thus raising the possible problem of sample selection bias as some of the unobserved factors affecting the participation decision may also affect the supply decision. The Heckman two-step procedure is used to test for sample selection bias in the labour supply model (Heckman 1979).[6] The results show that no sample selection bias is present, and therefore the OLS model of labour supply is an appropriate one to estimate.

The Irish National Farm Survey (NFS) data for 2002, consisting of 937 observations, are used to estimate these models. Most of the factors that were identified as affecting labour allocation decisions significantly in previous studies are recorded by the NFS. The system and size of farm as well as the number of livestock units are included as explanatory variables. Demographics of the farm household are also included in the model. To explore the effect of decoupling, the substitution and wealth effects have to be measured and therefore variables representing the return to farm labour and total household wealth are specified in the model. Returns to on-farm labour are estimated by dividing total farm income by total labour employed on the farm.[7] To

[6] For further details see Hennessy and Rehman (2005)

[7] In some cases the return was negative due to negative farm income; to avoid negative farm wages the variable was constrained to a lower limit of zero.

explore the effect of wealth, a variable representing non-labour income should be included in the model. The identification of such a variable is however problematic as the NFS does not collect any non-farm data; therefore in common with Mishra & Goodwin (1997) and Ahituv & Kimhi (2002) a farmer's net worth is used as a proxy for household wealth.[8] The variables used in the model are presented in Table 2.

**Table 2: Data for Labour Allocation Models**

| Variable | Definition | Sample Mean (N=937) | Standard Deviation (N=937) |
|---|---|---|---|
| | **Dependent Variables** | | |
| WORK | Dummy variable=1 if operator engages in off-farm employment | 0.26 | 0.44 |
| HOURS* | Number of hours supplied off-farm | 1481 | 678 |
| | **Independent Variables** | | |
| SYSTEM | Dummy variable=1 if farm is in dairy production | 0.52 | 0.49 |
| SIZE | Total agricultural area in hectares | 46 | 39 |
| SIZE2 | Agricultural Area Squared in hectares | 3571 | 17938 |
| FFI | Family Farm Income €000 | 22.8 | 22.05 |
| FWAGE | Family farm income per hour of total labour € | 11.38 | 10 |
| FWAGE 2 | Family farm income per hour of total labour squared € | 231 | 438 |
| LUS | Number of livestock units | 70 | 55 |
| LUS2 | Number of livestock units squared | 7928 | 14302 |
| AGE | Farmer's age in years | 55 | 12 |
| AGE2 | Farmer's age squared | 3148 | 1243 |
| SPJ | Dummy variable=1 if spouse engages in off-farm employment | 0.30 | .45 |
| NO | Number living in farm household | 3.9 | 1.8 |
| LAB | Number of unpaid labour units on the farm | 1.09 | 0.43 |
| UNEMP | Local unemployment rate in percentage | 4.6 | 0.86 |
| OWAGE* | Estimated Off-farm work wage per hour € | 14.34 | 11.89 |
| NW | Net Worth €000 | 434.25 | 348 |
| NW2 | Net Worth Squared €000 | 309564 | 872610 |

** Sample mean and standard deviation provided only for sample of 247, i.e. where HOURS>0*

[8] Some have argued that this is not an appropriate measure of wealth as many farmers tend to be asset rich but income poor; however, in the absence of any more appropriate verifiable data, there is no realistic alternative to using net worth.

The results of the labour participation and supply models are presented in Appendix 2. The effect of on-farm wage is as expected, negative but non-linear, suggesting that as the farm wage increases the probability of working off-farm declines but at a declining rate. The effect of farm size is also negative suggesting that operators of larger farms are less likely to participate in the off-farm labour market. The effect of the farming system is significant and negative suggesting that the presence of a dairy enterprise reduces the probability of working off farm by 0.31. Again, this is as expected as dairy farming is very labour intensive and is one of the more profitable farm enterprises in Ireland. The effect of the age variable is counter-intuitive in that as farmers get older the probability of off-farm employment increases, albeit at a declining rate. The effect of the labour variable is negative indicating that farms with more unpaid family labour units have a lower probability of the farmer engaging in off-farm employment. Finally, the non-labour income variable, net worth, is significant at the 1 percent level and is negative as expected, suggesting that an increase in non-labour income reduces the probability of off-farm employment.

The results of this labour supply model show that the on-farm wage, the farmers' net worth, the amount of unpaid labour on the farm and the number living in the farm household all affect the number of hours supplied to off-farm employment significantly. The effect of the farm wage and wealth variables are both negative as expected. It follows, therefore, that other things being equal, a decline in the on-farm wage - as is likely to occur following decoupling - increases the numbers working off-farm and the amount of time allocated to off-farm employment. Any increase in non-labour income, which is likely to occur, decreases the number of part-time farmers and hence the amount of time spent working off-farm. The effect of decoupling, therefore, depends on the extent of the decline in the on-farm wage and the increase in non-labour income. The initial estimates suggest that the probability of labour participation increases for 58 percent of the observations, while at the same time the number of hours spent on off-farm employment also increase for the majority of part-time farmers, with the average number of hours increasing from 1481 hours in the baseline situation to 1550 hours for a decoupled scenario.

**Modelling the Distribution of Milk Quotas**

The allocation of milk quota as distributed amongst different types of farms is modelled outside the LP framework because of the existence of institutional barriers as well as non-profit related factors influencing production decisions. Modelling the reallocation of milk quota is particularly important, as milk quota is one of the few factors over which the Irish government has complete control. The milk quota market is managed as the price at which quota is traded is set administratively and the redistribution of the existing quota is also state managed through spatial ring-fencing. Milk quota therefore, is of great interest to policy makers in Ireland as they can manipulate this policy instrument to achieve desired economic, social and political goals.

The farm level milk price will decline by approximately 10 percent from 2005 to 2012 as a result of the agreed reductions in the intervention prices for dairy products (Binfield et al 2003). The associated compensation will be decoupled from production meaning that producers giving up milk production in 2005 will still receive €0.04 per litre compensation in 2006 and onwards. Furthermore, producers remaining in production should no longer factor the €0.04/litre into the returns to their output as this payment is received regardless of production. The effect of the policy reform, therefore, is the erosion of the actual (coupled) returns to production and to milk quota. This erosion of the returns to production is likely to render dairy production unprofitable on many farms and, as a result, will have negative consequences for the number of producers. Previous studies of decoupling in the dairy sector suggest that the implications for farm numbers would be negative. Harvey and Colman (2003) concluded that milk producer numbers in the UK would fall by 21 percent in the period from 2002 to 2010 as a result of decoupling.

A model of dairy farmers' production decisions was estimated where farmers could make one of a discrete number of production decisions, maintain, increase, contract or cease milk production. Historical data from a panel of farms was used with the objective of estimating the types of farms that are most likely to change their production decisions. The objective was to simulate the demand for and supply of milk quota in the various regional quota markets. The lack of historical data that exist on farm however posed some problems; so, some additional data on farmers' future plans were collected. Again, problems were encountered as it was not possible to identify any factors that would affect farmers' future production plans significantly. The data collected could not be used to project what may happen in the future. Instead, it was necessary to resort to a farm profitability analysis to extrapolate future production decisions.

The number of farms exiting milk production was estimated as the numbers retiring without a successor and as well as those operating below the critical level of profitability below which exits from farming have occurred in the past. From these estimates the regional supply of milk quota was estimated. It was assumed that farmers with a marginal revenue exceeding marginal cost would demand additional milk quota. From these estimates the milk quota market was simulated and new quantities of milk quota per farm were projected. These milk quota estimates provide the right hand side parameters for the milk quota constraint in the LP models.

**Modelling the Reallocation of Land**

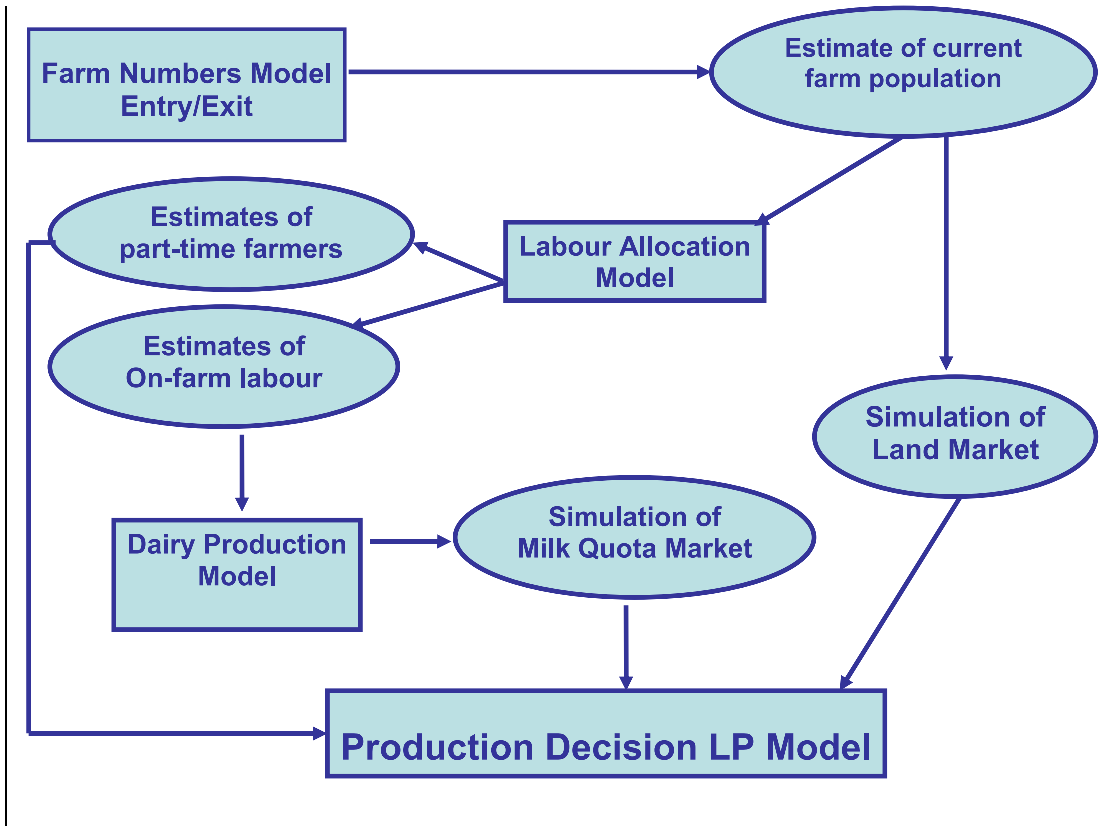
Structural change may result in the re-allocation of land as the resources of exiting farmers are redistributed among those who remain in farming. The retirement and succession models produce annual estimates of the number of farmers exiting production each year. The estimates of exiting farmers are used to develop regional land banks. The land left by each departing farmer enters a regional land bank and that land is then redistributed amongst expanding farms within the same region. The redistribution of such land banks is achieved by the LP models, which reallocate newly available land on a rental basis to the farms with the highest shadow values for land; that is, to those farms that can afford to pay the most. This transfer of land is a rental, rather than a permanent, transfer because of the complexities of annualising the cost of a permanent acquisition of land within a multi-period model.

It is assumed that land is reallocated only when a farm ceases production; further, all active farmers continue to farm the same land area as in the base period, with the exception of those acquiring the land that becomes available. It is a tenuous assumption, which may limit the final findings of this modelling exercise. It can however be argued that there may not be any significant change in the allocation of land as after decoupling. Under the MTR the decoupled payment is still linked to the land and, therefore, the farmer must keep 'farming' the land to qualify for the payment. Even the most inefficient farmer would have to be offered, at the minimum, the value of the decoupled payment less the compliance costs to induce him to lease out their land. The land rental prices in a decoupled scenario are therefore likely to reflect the value of the associated decoupled payment rather than the productive capacity of land. Farmers wishing to expand production beyond what they produced in the reference period will have to do so without any direct payments or financial support; therefore, the market based margins, after excluding the decoupled payment, that may be earned on rental land, in many cases may not be worthwhile.

**The Integrated Modelling Approach**

To recapitulate: in order to assess the impact of the MTR reform of the CAP, the above econometric models are integrated with individual farm level optimisation models. Figure 2 presents a schematic outline of how these models link together to form the integrated modelling system. The 'entry and exit' model estimates the number of active farms in any one year. The lands of farms that are estimated to exit production during the year enter the land simulation model and are reallocated to exiting farms wishing to expand. Following on from this, the econometric labour model is run in order to estimate the number of part-time farms and the amount of labour available on each farm. When labour estimates are available, the milk production decision model, this model, as explained above, is used to estimate the number of farmers exiting milk production and the amount of milk quota being reallocated to existing farms. In the final stage of the integrated modelling system, a generic multi-period LP model is specified for each farm in the dataset and production plans and farm incomes are simulated for each year covering a period over 2005 to 2010 for two scenarios: a baseline situation, which is the continuation of the Agenda 2000 reform, and the MTR scenario. Projections of prices and costs for the baseline and the decoupling scenarios are taken from the FAPRI-Ireland model (Binfield et al 2003). The input-output coefficients in the LP model are 'mean values' for the base year and remain constant throughout the projection period. In the MTR scenario direct payments are removed from the objective function and the Single Farm Payment (SFP) is the new source of revenue, due to decoupling, which is attached to land use. The choice set for this scenario includes the option of entitlement farming, which is the activity of using land to claim the SFP but not to produce any tangible products (Breen et al 2005).

**Figure 2: Schematic Outline of Integrated Modelling System**




**Results of the Two Scenario Runs**

Figure 2 shows the proportion of beef farmers participating in the off-farm labour market. Given inter-generational changes and a positive macroeconomic outlook, the number of farmers participating in off-farm employment will increase in both scenarios. The pace of structural change, however, is faster under the MTR scenario as the substitution effect dominates the wealth effect for the majority of farmers and therefore the numbers participating in off-farm employment increases when the payments are decoupled from production.

A mass de-stocking of animals and a proliferation of entitlement farming is predicted after decoupling. A closer analysis however suggests that such a change is not likely transpire. A large number of Irish beef farmers have been farming at a market loss and it was thought that they could maximise profits by de-stocking. But if overhead costs are still incurred, then most of such farmers would be acting rationally by continuing with some level of farm activity. A vast majority of them can obtain a gross profit from at least one enterprise and, post-coupling they would specialise in their most profitable enterprise. Figure 3 presents the projected number of entitlement farmers who would let their land go fallow and choose not produce any tangible agricultural output.

**Figure 2: Projections of the Proportion of Beef Farmers with Off-farm Employment in Ireland**

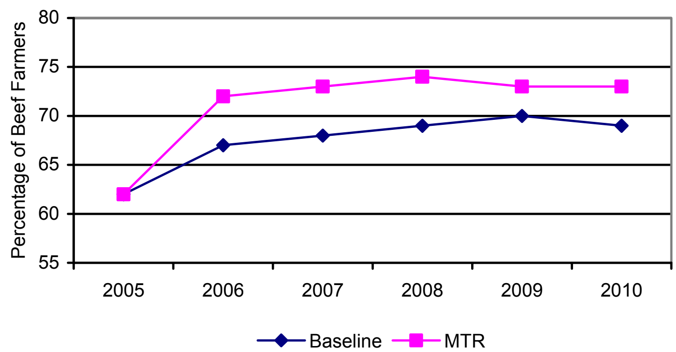



**Figure 3: Projections of Entitlement Beef Farmers in Ireland**


The impact of the MTR is likely to be inequitable and differentiated with some farmers benefiting and others losing, by adapting stratagems such as off-farm employment, enterprise substitution and/or specialisation, for example. It is important, therefore, to consider the full impact of decoupling on both the viability of the farm business and the sustainability of the household.

Such effects are assessed using a framework developed by Hennessy (2004), where an economically viable farm business is classified as one having (a) the capacity to remunerate family labour at the average agricultural wage, and (b) the capacity to provide an additional 5 per cent return on non-land assets (Frawley and Commins 1996). Farms that are not economically viable but where the farmer participates in off-farm employment are classified as nonviable but sustainable, as off-farm income contributes to the long-term sustainability of the household. Farmers that do not work off-farm and operate an economically nonviable business are considered vulnerable.

Table 3 shows the 2002 population of Irish beef farmers as projected population for 2010 for a baseline (continuation of Agenda 2000) and the MTR scenario. In 2002 just 17 percent of beef farms were economically viable; this number is projected to grow after decoupling as farmers benefit from higher beef prices and less market distortion. The number of viable farmers relying on outside income is also projected to increase. The number of nonviable but sustainable farms will almost double after decoupling, due to the declining importance of farm income to many farm households. Finally, the number of vulnerable farms would decline faster under decoupling than the baseline scenario because of the improved economic outlook for beef and the increased attraction of off-farm employment.

**Table 3: Viability of Beef Farming in Ireland**

| **Farm Group** | **2002** | **Baseline 2010** | **MTR 2010** |
|---|---|---|---|
| All Viable Farms<br>(percentage) | 10,363<br>(17) | 7,265<br>(12) | 11,500<br>(20) |
| *Of which are part-time*<br>*(percentage)* | *5,104*<br>*(8)* | *2,700*<br>*(5)* | *7,152*<br>*(12)* |
| Non-Viable Sustainable<br>(percentage) | 22,635<br>(38) | 38,355<br>(64) | 35,500<br>(61) |
| Vulnerable | 25,829 | 12,920 | 11,500 |

| | | | |
|---|---|---|---|
| (percentage) | (43) | (23) | (19) |
| All Farms | 58,828 | 58,600 | 58,002 |

Table 4 presents similar results for the dairy farming sector, where the effect of the MTR is less positive. The reduction in the intervention prices for dairy products means a considerable price/ cost squeeze, accelerating the rate of exit from this sector after the MTR relative to the baseline situation. The average level of milk production on dairy farms in 2002 was 230,000 litres, increasing to 34,000 litres by 2010 under the MTR scenario. Despite these increases in output, the number of economically viable dairy farmers will decline.

**Table 4: Viability of Dairy Farming in Ireland**

| Farm Group | 2002 | Baseline 2010 | MTR 2010 |
|---|---|---|---|
| Viable Farms (percentage) | 16,110 (57) | 15,200 (66) | 12,250 (66) |
| Viable Part-time (percentage) | 700 (2) | 500 (2) | - |
| Non-Viable Sustainable (percentage) | 2,000 (6) | 1,500 (7) | - |
| Transitional (percentage) | 10,700 (37) | 6,300 (27) | 6,500 (34) |
| All Farms | 28,800 | 23,000 | 18,750 |

## Discussion

The objective of the research presented in this paper was to model the effects of decoupling on structural change in Irish farming. Undertaking this research has proved challenging from a number of perspectives. First, modelling the effect of policy change on structural change in farming remains difficult methodologically. Aggregate models based on trend analysis provide little information about the interaction between policy instruments and structural change, while the more advanced econometrically estimated Markov Chain models are data intensive and are based on some very restrictive assumptions. Apart from the methodological difficulties associated with capturing the essence of structural change, modelling decoupling is problematic because of it being an unprecedented policy instrument and evidently it is too early to expect any empirical evidence on supply inducing effects of its implementation. The traditional partial equilibrium models based on historically estimated supply elasticities are of limited value in analysing the effects of decoupling. This paper has addressed the research questions posed at the beginning of the paper by using a farm level modelling approach. Linear programming is used as the analytical technique because of its ability to analyse unprecedented changes; but it is of little use in projecting structural changes, unless it is supplemented with a number of exogenously estimated models. The integrated modelling approach, using optimisation and econometric estimation, allows us to simulate changes in the farming population, the proportion of full and part-time farms, the number of dairy farms and the number of economically viable farm businesses under different policy scenarios. The approach developed shows the effect of decoupling on the number of economically viable businesses, on the sustainability of farm households and on the number of vulnerable households. Undoubtedly, there is still considerable scope for improvement within the modelling approach and capacity for future research: in particular, the lack of verifiable empirical data on the number of farmers who leave farming mid-career, that is, for reasons other than retirement, makes it difficult to simulate exits from farming other than those that are caused by retirement and non-succession. Further, data on factors that influence dairy farmers' decisions to exit the industry are scare, rendering the simulation of the milk quota market a very difficult task.

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**Appendix 1**

## Results of the Multinomial Logit Model of Occupational Choice

| Independent Variables | Part-time CHOICE=2 | | Non Farming CHOICE = 3 | | Don't Know CHOICE = 4 | |
|---|---|---|---|---|---|---|
| | Param. | z ratios | Param. | z ratios | Param. | z ratios |
| Intercept | 2.23** | 7.29 | -.668 | -1.15 | .7790* | 2.49 |
| UAA | -.0056 | -1.57 | -.0027 | -0.32 | -0.006* | -1.79 |
| LUS | -.0178** | - -4.64 | -.0215** | -2.66 | -0.0015 | -0.53 |
| FJOB | 1.399** | 2.88 | .5718 | 0.77 | .9002 | 1.70 |
| SJOB | .9046** | .9046 | 1.616** | 3.30 | 0.389 | 1.24 |
| DAIRY | -.9913** | -3.17 | .3430 | 0.63 | -0.4616 | 1.51 |
| HED3 | 1.163** | 2.91 | 1.561** | 2.81 | 0.7733* | 1.90 |

* Significant at 5%; ** Significant at 1%  N= 514  Pseudo R2 =0.178

Log Likelihood =-499.19  Unrestricted Log Likelihood = -607.7

Correct predictions:

CHOICE=1 (65%) CHOICE=2 (89%) CHOICE=3 (0) CHOICE=4 (31%)

Total Correct Predictions (65%)

## Marginal effects of Selected Explanatory Variables

| Independent Variables | Full-time CHOICE=1 | Part-time CHOICE=2 | Non-Farming CHOICE=3 | Don't Know CHOICE=4 |
|---|---|---|---|---|
| UAA | .0007 | -.0003 | .00009 | -.00049 |
| LUS | .0016 | -.0037 | -.00052 | .0026 |
| FJOB | -.133 | .1904 | -.0182 | -.0387 |
| SJOB | -.0962 | .1212 | .0534 | -.0784 |
| DAIRY | .1010 | -.1850 | .0459 | .0380 |
| HED3 | -.1194 | .1257 | .03532 | -.0416 |

**Results of the reduced bivariate probit model**

| Independent Variables | FULLTIME | | HED3 | |
|---|---|---|---|---|
| | Parameter | (t ratios) | Parameter | (t ratios) |
| Intercept | -.2333** | -4.09 | -.4464** | -5.02 |
| SJOB | - | - | .1947* | 2.19 |
| FFI | - | - | -.0177** | -6.68 |
| HED3 | -1.809** | -13.70 | | |

Rho (ρ) 0 .99** * ($p \leq 0.05$) ** ($p \leq 0.01$)

Number of Observations = 514 Log Likelihood = -484.80

## Appendix 2

### Results of the Probit Model of Labour Participation

| Variable | Coefficient (Z-Values) | Marginal Effect |
|---|---|---|
| Intercept | -1.136783 (-1.11) | |
| FWAGE*** | -.0284262 (-2.57) | -.007 |
| FWAGE2* | .0003971 (1.63) | .0001 |
| SIZE** | -.0060623 (-2.15) | -.0015 |
| SYSTEM*** | -1.210383 (-9.03) | -.3158 |
| AGE*** | .1234819 (3.08) | .0318 |
| AGE2*** | -.001633 (-4.26) | -.0004 |
| NO*** | .0849544 (2.78) | .0219 |
| NW*** | -.0008696 (-2.62) | -.00022 |
| NW2*** | 3.95e-07 (3.11) | 1.02e-07 |
| LAB** | -.3207875 (-1.92) | -.0828 |
| Pseudo $R^2$ = 0.324 | Correct Predictions = 80% | |
| Likelihood Ratio Statistic $\chi^2_{10}$ = 349.40*** | | |

N = 937; * Significant at 10%. ** Significant at 5%. *** Significant at 1%.

**Results of the Ordinary Least Squares Model of Labour Supply**

| Variable | Coefficient (T-Values) |
|---|---|
| Intercept*** | 2169.69 (19.86) |
| FWAGE** | -12.3749 (-2.02) |
| NW*** | -.6025994 (-2.53) |
| LAB*** | 434.0715 (-3.68) |
| $R^2$= 0.199 | F= 15.61*** |

N = 247; *(p < 0.1);** (p < 0.05);*** (p < 0.01)

## Authors' Biographical Details

Thia Hennessy is a senior research officer at the Rural Economy Research Centre, Teagasc in Ireland. She specialises in policy analysis for the agricultural sector. This paper is based on her PhD research which she conducted while studying at the University of Reading.

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