

# Modelling the Impact of Decoupling on Structural Change in Farming: Integrating Econometric Estimation and Optimisation

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**Abstract**

*Implementation of the Mid Term Review of the Common Agricultural Policy on farming in Europe is expected, and intended, to initiate structural changes in European agriculture. This impact of the agricultural policy reform will be triggered at the farm level with both up- and down-stream effects for agriculture in Europe. Modelling such a phenomenon is challenging. An integrated modelling approach, involving farm level optimisation models and exogenously estimated econometric models of farmer behaviour, is developed for Ireland; this framework is a general one and is applicable elsewhere. Entry and exit from farming, postulated as the main consequences of the policy reform, are estimated exogenously to determine their role in the allocation of farm labour. The results for Ireland show that farm numbers will decline more rapidly under decoupling relative to a baseline situation. Further, decoupling is likely to favour beef farming but, an increasing number of beef farmers will have to rely on outside income to sustain that system of farming. Dairy farmers will face a price cost squeeze and structural change in this sector will be accelerated.*

**Keywords:** *Common Agricultural Policy, Decoupling, Farm Level Modelling, Linear Programming, Succession, Labour Allocation*

**JEL Classification:** *C6; Q12; Q15; Q58*

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

## **Introduction**

The Mid Term Review reform of the Common Agricultural Policy (CAP) 'decouples' (or disconnects) direct support from production. Irish farmers have depended on direct payments for a considerably long period, with a majority receiving over 100 percent of their total farm income as direct payment; thus, 'decoupling' will have major ramifications for production and the structure of farming. This paper presents a modelling approach developed in Ireland to assess the impact of decoupling.

## **Background to Decoupling**

If coupled subsidies are replaced with decoupled ones then production should fall to a level that would exist without any subsidies; therefore, farm output that makes a market-based loss should fall substantially, unless significant cost or efficiency gains are achieved. Research has shown that even fully decoupled payments have production inducing effects through their impact on farmers' exposure to risk, their access to capital and their future expectations of 're-coupling' of support. For example, if the payments are linked to resource use then an incentive to produce may still exist (Swinbank 2004). Furthermore, decoupling may relax a household's budget constraint, inducing a farmer to take riskier production decisions (Hennessy 1998) or to invest on the farm (Anderson 2004). This paper explores the effect of decoupled payments on farmers' production decisions and on the pace of structural change in farming. Decoupling is an unprecedented change and therefore past data provide little indication of its supply inducing effects, presenting agricultural policy modellers with a considerable challenge. The traditional tools of analysis, such as partial or general equilibrium models, use supply

elasticities derived from time-series are not suited to assess the impact of decoupling. For analysing 'farm-focused' policies, a micro level approach, as presented in this paper, is what is required.

## **Methodology**

The FAPRI-Ireland Partnership is a set of commodity market models and a set of farm level models. The aggregate models, which are linked to the FAPRI EU GOLD model, are individually estimated econometric models that are solved simultaneously under different policy scenarios. The farm level models are structured around a generic multi-period profit maximisation Linear Programming (LP) model that is supplemented with a number of exogenously estimated econometric models of farmer behaviour. The farm level models apply price and cost projections emanating from the aggregate models to farm level data in order to simulate farmer adjustments after the policy reforms.

Optimisation is preferred as it does not rely on time-series and it does not extrapolate future from historical relationships; unprecedented policy changes can therefore be analysed. The normative assumption of optimisation models is mitigated through the use of econometric estimation of 'entry to and exit from' farming and of farm labour allocation. These estimations quantify the effects of non-pecuniary factors on farmers' decisions, providing "positive" estimates of farm numbers and resource allocation following decoupling. This integrated approach is explained below.

## **Modelling Entry to and Exit from Farming**

Many studies of entry to and exit from farming conclude that age related variables are the most significant determining factors of this phenomenon (for example see Gale (2002) and Glauben et al (2002)). An age cohort analysis of the Irish data shows that farm numbers are in net decline, as the number of retiring farmers exceeds new entrants. Models of retirement and succession in farming

are required to understand the effect of policy reform on the number of farms; however, empirical data on retirement from farming in Ireland is extremely limited and therefore it is not possible to model this decision statistically. The data on succession, however, are better and a succession model is specified in the context of the nominated farm heir's occupational choice, using the Schmidt and Strauss (1975) theory of occupational choice. Such choices are made by comparing the discounted utilities derived from all alternative occupations available over a life-cycle. For the Irish situation, the nominated heir has three choices: enter farming, enter a non-farming occupation or enter farming part-time. The probability of each choice being made is estimated by a multinomial logit (MNL), using the Irish National Farm Survey (NFS) data on farmers' succession plans and the heirs' occupational choices.

The results show that educational attainment, especially participation in tertiary education, significantly influences the occupational choice. Participation in tertiary education and occupational choice are very likely to be 'joint' and they may not vary autonomously. A bivariate probit model that controls such endogeneity is specified and shown in Appendix I. Nominated farm heirs with third level education are significantly less likely to enter farming and the decision to participate in tertiary education is influenced negatively by farm income. Hence, if farm incomes drop due to decoupling, the probability of heirs participating in tertiary education will increase as would the chances of their exit from farming.

### **Modelling Farm Labour Allocation**

Decoupling is expected to lead to a decline in the return to farm labour and thus trigger a movement of labour from agriculture to other sectors of the economy. An econometric model of

farm labour allocation quantifies the implications for (i) the number of part-time farmers and (ii) the availability of farm labour. Labour allocation decisions have their conceptual basis in the agricultural household model (Singh, Squire and Strauss 1986). In this paper however the emphasis is on the role of government subsidies in this agricultural household decision-making. Coupled subsidies by their nature increase the marginal value product of farm labour. Decoupling however will lead to a decline in the return to farm labour and, other things being equal, farmers will substitute off-farm employment for farm work, resulting in the substitution effect. As a decoupled subsidy is not attached to production, it is a source of non-labour income, implying a relaxation of the household budget constraint, which permits a farmer to enjoy greater leisure while maintaining consumption and thus enjoy the so-called wealth effect. Decoupling may cause two conflicting effects. To measure the wealth and substitution effects, a labour participation and a labour supply model are specified separately (Hennessy and Rehman 2005), using a binary probit and OLS specifications to solve the two models respectively. The dependent variable in the OLS model, the number of hours worked off-farm, is incidentally truncated, as for some farmers the number of hours recorded is zero, raising the possibility of sample selection bias; therefore, a Heckman two-step procedure is applied to test and control the sample selection bias. The data used and the results are presented in Appendix 2.

To measure the substitution effect, returns to on-farm labour are estimated by dividing total farm income by total labour employed on the farm<sup>1</sup> and, for wealth effect, a variable representing non-labour income is required. The identification of such a variable is difficult as the NFS does not

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<sup>1</sup> In some cases the return was negative as a negative farm income was recorded, to avoid negative farm wages the variable was constrained to a lower limit of zero.

provide any data pertaining to non-farm activities. Instead, following Mishra and Goodwin (1997), a farmer's net worth is used as a proxy for household wealth.<sup>2</sup> The effects of the on-farm wage and wealth variables are both negative; and, the return to labour declines and both the wealth and part-time farmers increase due to decoupling, as expected. The direction of movement of a farmer's labour between on- and off-farm employment therefore depends on the changes on individual farms. The probability of participation in off-farm employment increases in 58 percent of cases, while the number of hours spent on off-farm employment also increases for the majority of part-time farmers. The impacts for individual farms are discussed later after the description of the integrated modelling approach.

### **The Integrated Modelling Approach**

To assess the impact of the MTR reform of the CAP, the above econometric models are integrated with individual farm level optimisation models. The 'entry and exit' model estimates the number of active farms in any one year and for each farm a Linear Programming (LP) model is run. The econometric labour model estimates the number of part-time farms and the amount of labour available on each farm. Projections of prices and costs for the baseline and the decoupling scenarios are taken from the FAPRI-Ireland model (Binfield et al 2003). The resources of the exiting farms, land, labour and milk quota, are allocated using a generic multi-period LP model and production plans are generated for each year covering a period over 2005 to 2010 for three scenarios: a baseline situation, the previous Agenda 2000 reform and the new decoupling (MTR) reform of the CAP. The input-output coefficients are as recorded in the base year remain constant and all resource endowments are as recorded in the baseline scenario. In the MTR scenario direct

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<sup>2</sup> Some researchers argue that this is not appropriate as many farmers tend to be asset rich but income poor. In the absence of a better alternative, however, net worth is used here.

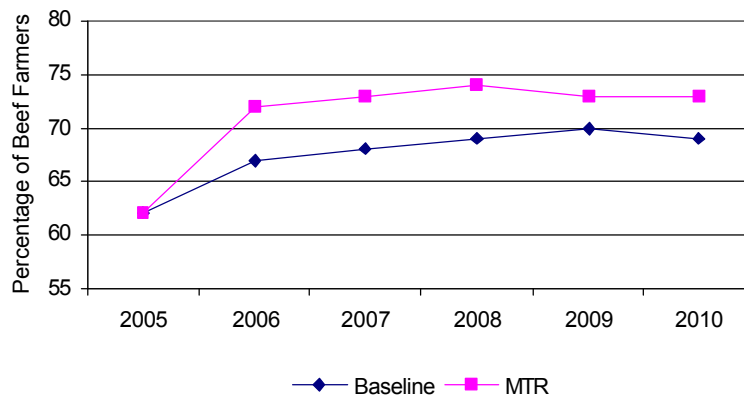


payments are removed from the objective function and the Single Farm Payment (SFP) is the new source of revenue, due to decoupling, which is attached to land use. The choice set for this scenario includes the option of entitlement farming, which is the activity of using land to claim the SFP but not to produce any tangible products (Breen et al 2005).

## Results

Figure 1 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. 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.

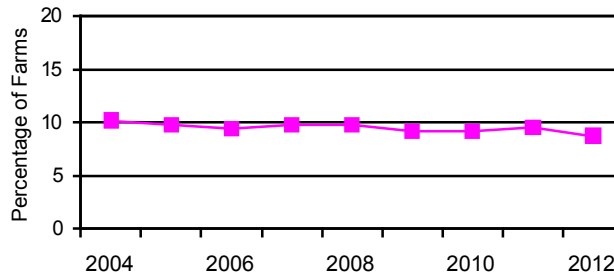
**Figure 1: Projections of the Proportion of Beef Farmers with Off-farm Employment in Ireland**



A mass de-stocking of animals and a proliferation of entitlement farming is predicted due to decoupling. A closer analysis will however suggest that such a change is not likely to occur. 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. However, if overhead costs are still incurred, then for most

of these farmers it would be rational to continue with some level of farm activity. A vast majority can obtain a gross profit from at least one enterprise and post-coupling such farmers would specialise in their most profitable enterprise. Figure 2 presents the projected number of entitlement farmers.

**Figure 2: Projections of Entitlement Beef Farmers in Ireland**



The impact of the MTR is likely to be inequitable as some farmers will benefit while others lose, 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 of decoupling 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. Economically nonviable farms with another source of income are vulnerable.

Table 1 shows the current beef farming population and the projected changes in the baseline and MTR scenarios. In 2002 just 17 percent of beef farms were economically viable. They are projected

to grow under decoupling, as farmers benefit from higher beef prices and less market distortion; however, the number of viable farmers relying on outside income is 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 1: Viability of Beef Farming in Ireland**

<b>Farm Group</b>	<b>2002</b>	<b>Baseline 2010</b>	<b>MTR 2010</b>
All Viable Farms (percentage)	10,363 (17)	7,265 (12)	11,500 (20)
<i>Of which are part-time</i> (percentage)	5,104 (8)	2,700 (5)	7,152 (12)
Non-Viable Sustainable (percentage)	22,635 (38)	38,355 (64)	35,500 (61)
Vulnerable (percentage)	25,829 (43)	12,920 (23)	11,500 (19)
All Farms	58,828	58,600	58,002

Table 2 presents similar results for the dairy farming, 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 production on dairy farms in 2002 was 230,000 litres which will increase 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 2: Viability of Dairy Farming in Ireland**

<b>Farm Group</b>	<b>2002</b>	<b>Baseline 2010</b>	<b>MTR 2010</b>
Viable Farms (percentage)	16,110 (57)	15,200 (66)	12,250 (66)
Viable PT (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

## **Conclusions**

This paper has developed a farm-level modelling approach to assess the effects of the MTR reform of the CAP on Irish farming. It is shown that the farm numbers will decline more rapidly under decoupling relative to the baseline situation. Decoupling is likely to result in a more positive economic outlook for beef farming but the number of beef farmers relying on outside income will increase. Dairy farmers will face a price cost squeeze and the pace of structural change in that sector will be accelerated after decoupling. The proposed approach integrating econometric models with farm level optimisation provides a versatile tool for analysing the impact of changes in agricultural policies.

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## Appendix 1

**Table A1.1: 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.*

**Table A1.2: 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

\* ( $P \leq 0.1$ ) \*\*\* ( $P \leq 0.05$ ) N= 514 Pseudo R<sup>2</sup> =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%)

**Table A1.3: Results of bivariate probit model**

Independent Variables	FULLTIME		HED3	
	Parameter	(z ratios)	Parameter	(z ratios)
Intercept	-.6212	-5.38	-.5876	-5.04
LAND	.0023	1.57	-.00028	-0.17
LUS	.00186	1.05	-.0019	-0.93
FJOB	-	-	.1342	1.412
SJOB	-	-	.1983**	2.30
DAIRY	-.1928	1.42	.1019	0.64
FFI	.0011	0.31	-.0088**	-2.22
HED3	-1.847*	-13.8	-	-

Rho ( ) 0.98\*\*      \* ( $p \leq 0.05$ )      \*\* ( $p \leq 0.01$ )  
 Number of Observations = 514      Log Likelihood = -465.27

## Appendix 2

**Table A2.1: Data for Labour Allocation Models**

Variable	Definition	Sample Mean (N=937)	Standard Deviation (N=937)
<b>Dependent Variables</b>			
WORK	Dummy variable=1 if operator engages in off-farm employment	0.26	0.44
HOURS*	Number of hours supplied off-farm	1481	678
<b>Independent Variables</b>			
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



**Table A2.2: 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 <sup>2</sup> = 0.324		Correct Predictions = 80%
Likelihood Ratio Statistic $\chi^2_{10} = 349.40^{***}$		

N = 937; \* ( $p \leq 0.1$ ) \*\* ( $p \leq 0.05$ ) \*\*\* ( $p \leq 0.01$ )

**Table 12.3: 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 <sup>2</sup> = 0.199      F = 15.61***	

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